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Daily report 28-05-2020

Analysis and prediction of COVID-19 for EU-EFTA-UK and other countries

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Foreword

The present report aims to provide a comprehensive picture of the **pandemic situation of COVID-19** in the EU countries, and to be able to foresee the situation in the next coming days.

We employ an **empirical model**, verified with the evolution of the number of confirmed cases in previous countries where the epidemic is close to conclude, including all provinces of China. The model does not pretend to interpret the causes of the evolution of the cases but to permit the **evaluation of the quality of control measures made in each state** and a **short-term prediction of trends**. Note, however, that the effects of the measures' control that start on a given day are not observed until approximately 7-10 days later.

The model and predictions are based on two parameters that are daily fitted to available data:

- ✓ *a*: the velocity at which spreading specific rate slows down; the higher the value, the better the control.
- ✓ *K*: the final number of expected cumulated cases, which cannot be evaluated at the initial stages because growth is still exponential.

We show an individual report with 8 graphs and a table with the **short-term predictions** for different countries and regions. We are adjusting the model to **countries and regions** with at least 4 days with more than 100 confirmed cases and a current load over 200 cases. The **predicted period** of a country depends on the number of datapoints over this 100 cases threshold, and is of 5 days for those that have reported more than 100 cumulated cases for 10 consecutive days or more. For short-term predictions, we assign higher weight to last 3 points in the fittings, so that changes are rapidly captured by the model. The whole methodology employed in the inform is explained in the last pages of this document.

In addition to the individual reports, the reader will find an initial dashboard with a brief analysis of the situation in EU-EFTA-UK countries, some summary figures and tables as well as **long-term predictions** for some of them, when possible. These long-term predictions are evaluated without different weights to data-points. We also discuss a specific issue every day.

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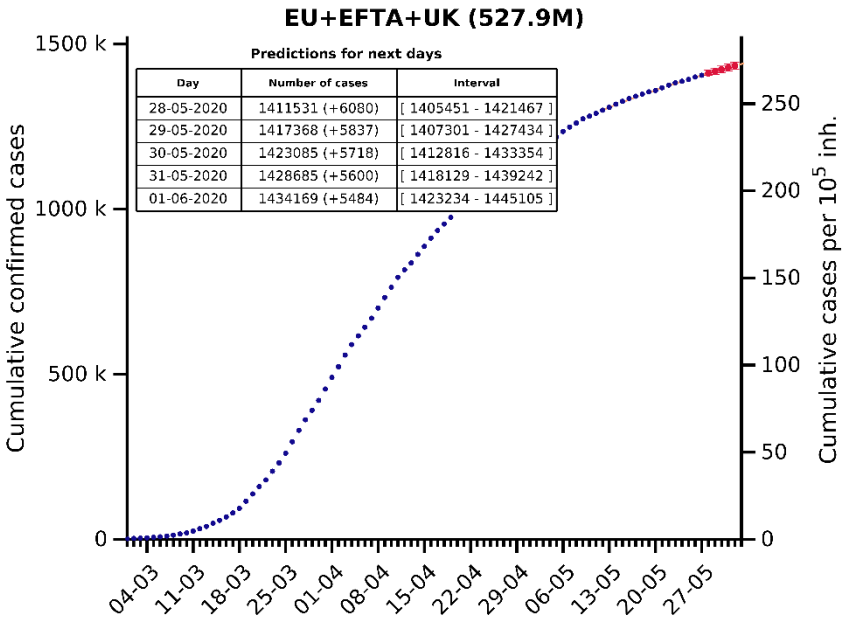
Disclaimer: These reports have been written by declared authors, who fully assume their content. They are submitted daily to the European Commission, but this body does not necessarily share their analyses, discussions and conclusions.

(0) Executive summary – Dashboard

Global EU+EFTA+UK trends and needs

The media are explaining that in the USA there are already more than 100,000 deaths due to Covid-19. Globally, more than 5.5 million confirmed cases have already been counted (25% of cases in EU+EFTA+UK), and more than 350,000 deaths have been reported. Among these, more than 160,000 in EU+EFTA+UK so far, i.e., 47% of the total. It was unimaginable a few months ago when the epidemic killed about 3,500 people in China.



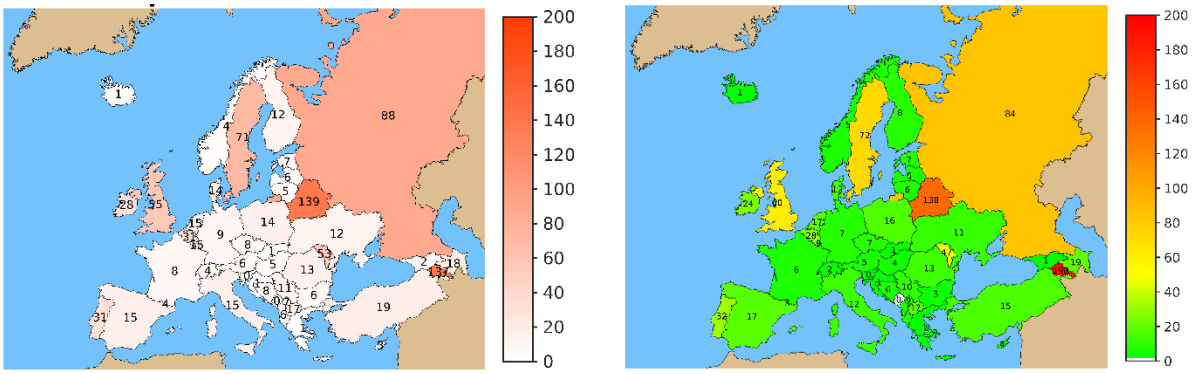
Now, **this epidemic's wave is entering the tail in most of countries** except the UK and Sweden. This tail is situating at different levels depending on the country. Spain is at the level of 500-600 daily new cases, in a similar range as Italy. Germany would be around 400-500, while France and Poland are reporting 300-400. Belgium and Portugal are at a similar level, 200-300. Finally, Netherland and Romania are around 100-200 daily new cases. Remaining countries would be below 100.

The analysis is focused on the changes in mobility in two Spanish provinces (Barcelona and Madrid) during the different phases of confinement.

Trends for specific countries

The situation and trends of countries is similar to the one reported yesterday.

The map in the left shows current **A_{14}**. The map in the right shows current **EPG**.



Situation and trends per country

Table of current situation in EU countries. Colour scale is relative except when indicated, this means that it is applied independently to each column, and distinguishes best (green) form worst (red) situations according to each of the variables. Last column (**EPG_{EST}**) indicates EPG assessed with **estimated real 14-day attack rate** (see report from 22/04 for details). **EPG_{REP}** is calculated with **data reported by countries**. EPG_{REP} and EPG_{EST} **cannot be compared between them** because scales are different, but can be independently used for estimating risk of countries according to reported or estimated real situation, respectively.

	Reported data								Indexes		
Country	Cumulative cases	Attack rate /10^5 inh.	Cumulative deaths	Mortality /10^5 inh.	Active cases (last 14 days)	14-day attack rate /10^5 inh.	Estimated active cases (last 14 days)	Estimated 14-day attack rate /10^5 inh.	ρ_7 [1]	EPG_{REP} [2]	EPG_{EST} [3]
United Kingdom	267,240	402.2	37,460	56.4	37,535	56.5	546,402	804.9	1.09	61	873
Spain	236,769	510.9	27,118	58.5	8,078	17.4	92,391	196.5	1.05	18	207
Italy	231,139	388.9	33,072	55.6	9,035	15.2	130,731	216.2	0.80	12	172
Germany	179,717	219.4	8,411	10.3	7,478	9.1	36,628	43.7	0.82	7	36
France	145,746	225.2	28,596	44.2	5,012	7.7	99,302	152.1	0.76	6	116
Belgium	57,592	507.1	9,364	82.4	3,611	31.8	59,595	514.2	0.89	28	455
Netherlands	45,768	269.4	5,871	34.6	2,557	15.1	33,155	193.5	1.12	17	216
Sweden	35,088	356.7	4,220	42.9	7,179	73.0	92,481	915.7	1.02	74	933
Portugal	31,292	301.7	1,356	13.1	3,160	30.5	14,346	140.7	1.02	31	143
Switzerland	30,678	358.0	1,647	19.2	348	4.1	1,848	21.4	0.61	2	13
Ireland	24,803	524.8	1,631	34.5	1,402	29.7	8,899	180.2	0.84	25	152
Poland	22,473	58.8	1,028	2.7	5,269	13.8	27,364	72.3	1.12	15	81
Romania	18,594	94.0	1,219	6.2	2,592	13.1	17,953	93.3	0.94	12	87
Austria	16,515	189.6	645	7.4	551	6.3	2,224	24.7	0.83	5	20
Denmark	11,480	201.0	565	9.9	813	14.2	4,109	70.9	0.86	12	61
Czech Republic	9,086	85.6	317	3.0	817	7.7	3,026	28.3	0.96	7	27
Norway	8,383	156.2	235	4.4	225	4.2	648	12.0	1.32	6	16
Finland	6,692	121.6	313	5.7	638	11.6	3,165	57.1	0.68	8	39
Luxembourg	4,001	694.6	110	19.1	97	16.8	269	43.0	0.61	10	26
Hungary	3,816	39.1	509	5.2	436	4.5	6,137	63.5	0.79	4	50
Greece	2,903	26.0	173	1.5	143	1.3	866	8.3	0.75	1	6
Bulgaria	2,460	34.5	133	1.9	391	5.5	2,251	32.4	0.57	3	19
Croatia	2,244	53.3	101	2.4	31	0.7	142	3.5	0.80	1	3
Estonia	1,840	140.2	66	5.0	89	6.8	NA	NA	1.02	7	NA
Iceland	1,805	495.5	10	2.7	3	0.8	NA	NA	0.86	1	NA
Lithuania	1,647	56.6	66	2.3	142	4.9	NA	NA	1.09	5	NA
Slovakia	1,515	27.8	28	0.5	46	0.8	NA	NA	1.55	1	NA
Slovenia	1,471	70.8	107	5.1	7	0.3	52	2.5	0.64	0	2
Latvia	1,057	53.6	23	1.2	106	5.4	NA	NA	0.91	5	NA
Cyprus	939	80.3	17	1.5	34	2.9	NA	NA	1.36	4	NA
Malta	615	143.4	7	1.6	107	24.9	NA	NA	NA	NA	NA
Liechtenstein	83	215.3	1	2.6	0	0.0	NA	NA	NA	NA	NA
	Scale										
	Worst	Worst	Worst	Worst	Worst	Worst	Worst	Worst	2.0	100	1000
	Best	Best	Best	Best	Best	Best	Best	Best	0.0	0	0

[1] ρ_7 is the average of 7 consecutive ρ, but can still fluctuate. [2,3] EPG stands for Effective Growth Potential. EPG_{REP} is obtained by multiplying attack rate of last 14 days per 10^5 inhabitants (i.e. density of cases) by ρ_7 (a value related with effective reproduction number and that, therefore, determines the dynamics for subsequent days). EPG_{EST} is obtained by multiplying estimated real attack rate of last 14 days per 10^5 inhabitants by ρ_7.

Highlights for countries with highest number of reported cases

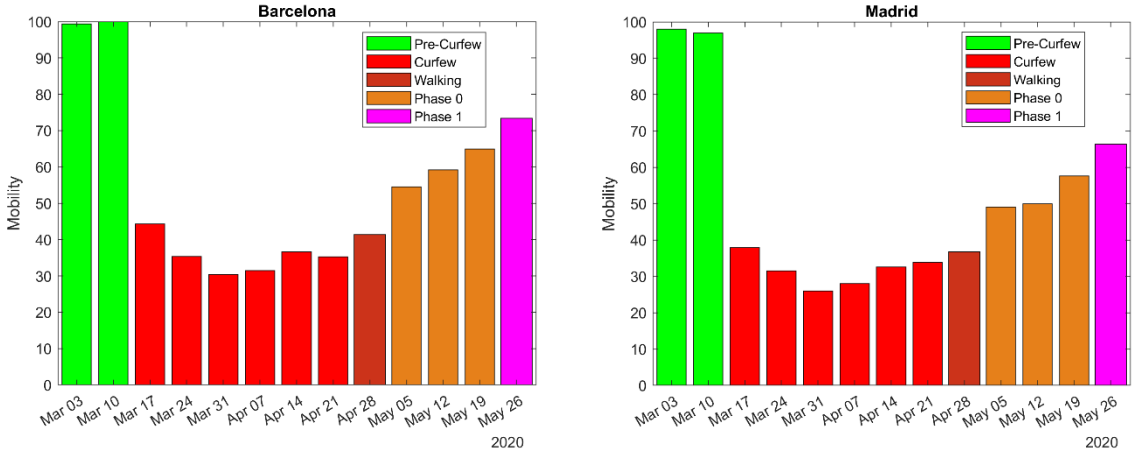
- ✓ Spain is reviewing all historical data and reports a decrease in deaths as a consequence of this revision. There are also a few inconsistences in reported cases that will persist until complete revision is finished.
- ✓ Italy, Germany and France maintain the trends of previous days.
- ✓ UK has not persisted in yesterday's increase. Therefore, the hypothesis of a delay in reporting seems feasible. Nevertheless, ρ_7 is affected by this one-day peak.

Analysis: How has people been moving under different confinement conditions?

During this epidemic, countries' governments have been applying several control measures in an attempt to stop its increase and facilitate its slowing down. Most of these measures have been related with limitations in citizen's movement and social interactions, so that contagious chains could be broken. Last weeks, the peak in the epidemic has been overcome in most of the countries, daily new cases have been persistently decreasing and they are gradually entering the final tail of this wave. Therefore, control measures are being relaxed as well.

Data about mobility and confinement degree provided by Facebook (Data for Good) allow for a tracking of people's behaviour from the movement perspective. The analysis of this data provides a variable of interest for risk evaluation. **An increase in mobility, or a decrease in confinement degree, entails an increase in social interactions that could eventually facilitate the spreading of a new outbreak** (i.e., a secondary wave). Then, it is important to ensure a **gradual increase in mobility that allows for a careful evaluation of resulting spreading rate**. If a significant and persistent increase in spreading rate is observed, control measures should be hardened again in the affected regions or areas.

We have evaluated how mobility and confinement degree has evolved in two Spanish provinces: Barcelona and Madrid. In particular, we are interested on studying **how mobility and confinement degree have changed depending on the control measures that were taken in each moment**. Next figures show the mobility in Barcelona and Madrid on consecutive Tuesdays. The index is expressed as percentage of mobility with regards to the baseline of each province (i.e., 100 % mobility entails that mobility is the same as usual, while 50 % mobility would express that it is reduced to the half).

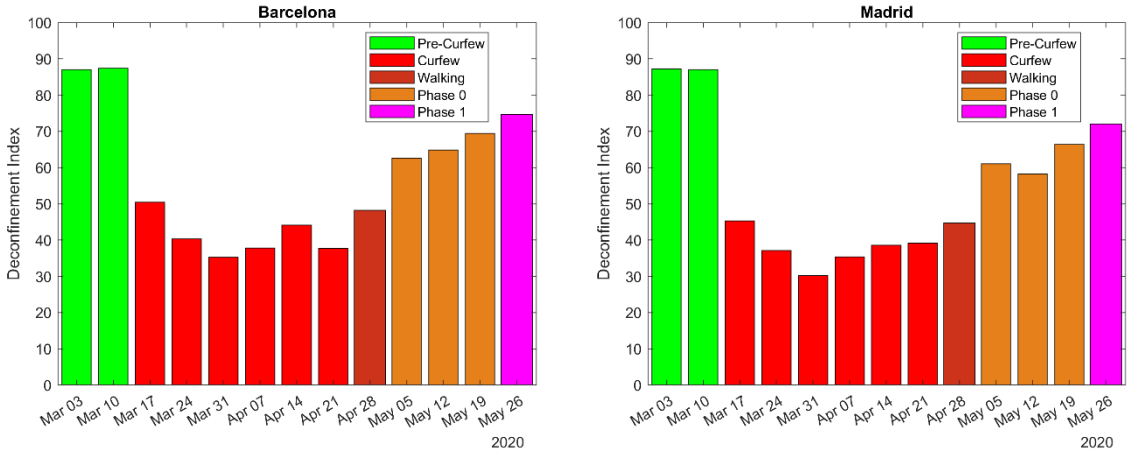


The main features of the phases shown in the legend are the following:

- Curfew: it was applied for 6 weeks. First 2 weeks and last 2 weeks, non-essential workers were allowed to move to workplace when working at distance was not possible. The 2 intermediate weeks, only essential workers were allowed to move.
- Walking: short and regulated walks of children were allowed, with several restrictions.
- Phase 0: adults short walks and outdoor sport activities were allowed, with several restrictions. Small businesses were able to open if they could offer appointments.
- Phase 1: journeys inside own province allowed. Bars and restaurants can operate only in exterior tables. Small businesses are able to open without appointments.

As seen in the figures, the **mobility degree agrees with applied measures**. The reduction in mobility during curfew was undoubtable, since it fell to the level of 30 % of baseline. Subsequent increase in mobility was more gradual in Barcelona where, despite being on Phase 0 for 3 weeks, mobility increased from week to week. In Madrid, significant increase was shown on the third week in Phase 0, when some of the measures were slightly relaxed by the government. This week, when Phase 1 is already effective, mobility has been around 73 % of the baseline in Barcelona and around 66 % in Madrid. In fact, the decrease in mobility seems slightly stronger in Madrid than in Barcelona in most of the weeks. Nevertheless, conclusions are tricky because each province has its own baseline, and it is therefore difficult to compare values.

Facebook – Data for Good provides another interesting index to evaluate confinement. This index accounts for the people that remains in a tile of approximately 600 m per 600 m. Then, the resulting number indicates the percentage of people that moves from this tile, i.e., the percentage of people that is not confined at a short-walk distance. These are the figures for Barcelona and Madrid provinces during last weeks.



The degree of deconfinement shown by these figures is also coherent with the different phases. In this case, since no baseline is used for the evaluation of the index, the obtained percentages are comparable. Pre-curfew period indicates that around 87 % of the people is usually deconfined, i.e., they move out of the tile. The minimum deconfinement (i.e., maximum confinement level) was achieved on the third week of the curfew. That week, only 35 % of Barcelona's citizens and 30 % of Madrid's citizens moved out from their tiles. Again, Barcelona was slightly above Madrid's on level of deconfinement during the whole process (between 2 and 5 points, on average). Both provinces have increased deconfinement degree. They are now around 40 points above the minimum but still 12-15 points below usual deconfinement.

These trends should be now matched with the evolution in new cases and spreading rate during these weeks. Nevertheless, Spanish government is currently revising historical data series so they cannot be used for this purpose, yet. In any case, the release of hardest measures is entailing an increase in mobility and, therefore, in social interactions. Now, the main concern is about the detection of possible secondary outbreaks, which would be driven by such increase in social interactions. Nevertheless, **it is expected that individuals' awareness on the Covid-19 dynamics facilitates the incorporation of individual measures such as the use of masks, the maintenance of wider physical distances on interactions and the more frequent hands' washing**.

Situation and trends in other countries

Table of current situation in a sample of non-EU countries. Colour scale is relative except when indicated, this means that it is applied independently to each column, and distinguishes best (green) form worst (red) situations according to each of the variables. EPG_{REP} and EPG_{EST} **cannot be compared between them** because scales are different, but can be independently used for estimating risk of countries according to reported or estimated real situation, respectively.

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Country	Cumulative cases	Attack rate /10^5 inh.	Cumulative deaths	Mortality /10^5 inh.	Active cases (last 14 days)	14-day attack rate /10^5 inh.	Estimated active cases (last 14 days)	Estimated 14-day attack rate /10^5 inh.	ρ_7 [1]	EPG_{REP} [2]	EPG_{EST} [3]
United States of America	1.699.933	513,6	100.442	30,3	309.187	93,4	1.956.526	591,1	0,96	89	565
Brazil	411.821	193,7	25.598	12,0	222.847	104,8	1.637.654	770,4	1,17	123	905
Russia	370.680	254,0	3.968	2,7	128.409	88,0	NA	NA	0,96	84	NA
India	158.333	11,7	4.531	0,3	80.330	5,9	275.549	20,4	1,24	7	25
Iran	141.591	168,6	7.564	9,0	28.866	34,4	163.367	194,5	1,03	35	200
Peru	135.905	412,2	3.983	12,1	59.599	180,8	204.576	620,5	1,10	198	681
Canada	87.508	231,9	6.765	17,9	15.230	40,4	135.881	360,0	0,96	39	345
Chile	82.289	430,5	841	4,4	47.908	250,6	102.237	534,8	1,44	361	770
Saudi Arabia	78.541	225,6	425	1,2	33.711	96,8	NA	NA	0,93	90	NA
Mexico	78.023	60,5	8.597	6,7	37.837	29,3	542.489	420,8	1,21	35	508
Pakistan	61.227	27,7	1.260	0,6	25.439	11,5	59.020	26,7	1,06	12	28
Qatar	48.947	1.698,9	30	1,0	22.408	777,8	NA	NA	1,09	850	NA
Belarus	38.956	412,3	214	2,3	13.131	139,0	NA	NA	0,99	138	NA
Ecuador	38.103	216,0	3.275	18,6	7.617	43,2	79.050	448,0	0,78	34	348
Argentina	13.920	30,8	500	1,1	7.054	15,6	44.538	98,5	1,78	28	175
	Scale										
	Worst	Worst	Worst	Worst	Worst	Worst	Worst	Worst	2,0	100	1000
	Best	Best	Best	Best	Best	Best	Best	Best	0,0	0	0

[1] ρ_7 is the average of 7 consecutive ρ, but can still fluctuate. [2,3] EPG stands for Effective Growth Potential. EPG_{REP} is obtained by multiplying attack rate of last 14 days per 10^5 inhabitants (i.e. density of cases) by ρ_7 (a value related with effective reproduction number and that, therefore, determines the dynamics for subsequent days). EPG_{EST} is obtained by multiplying estimated real attack rate of last 14 days per 10^5 inhabitants by ρ_7.

Disclaimer: estimated active cases and estimated 14-day attack rate are assessed by assuming a lethality of 1 % (see report from 20 to 24 April, #37-41). This value can change in countries where suspicious deaths are reported as well (real values would be lower) and in countries where incidence among elderly people was minor (real values would be higher).

Time indicators by country

These tables summarize a few time indicators for each country: time since 50 cases were reported, time interval between an attack rate of $1/10^5$ inhabitants and an attack rate of $10/10^5$ inhabitants, and time interval between attack rates of 10 to 100 per 10^5 inhabitants (only for countries that have overtaken this threshold).

EU+EFTA+UK countries

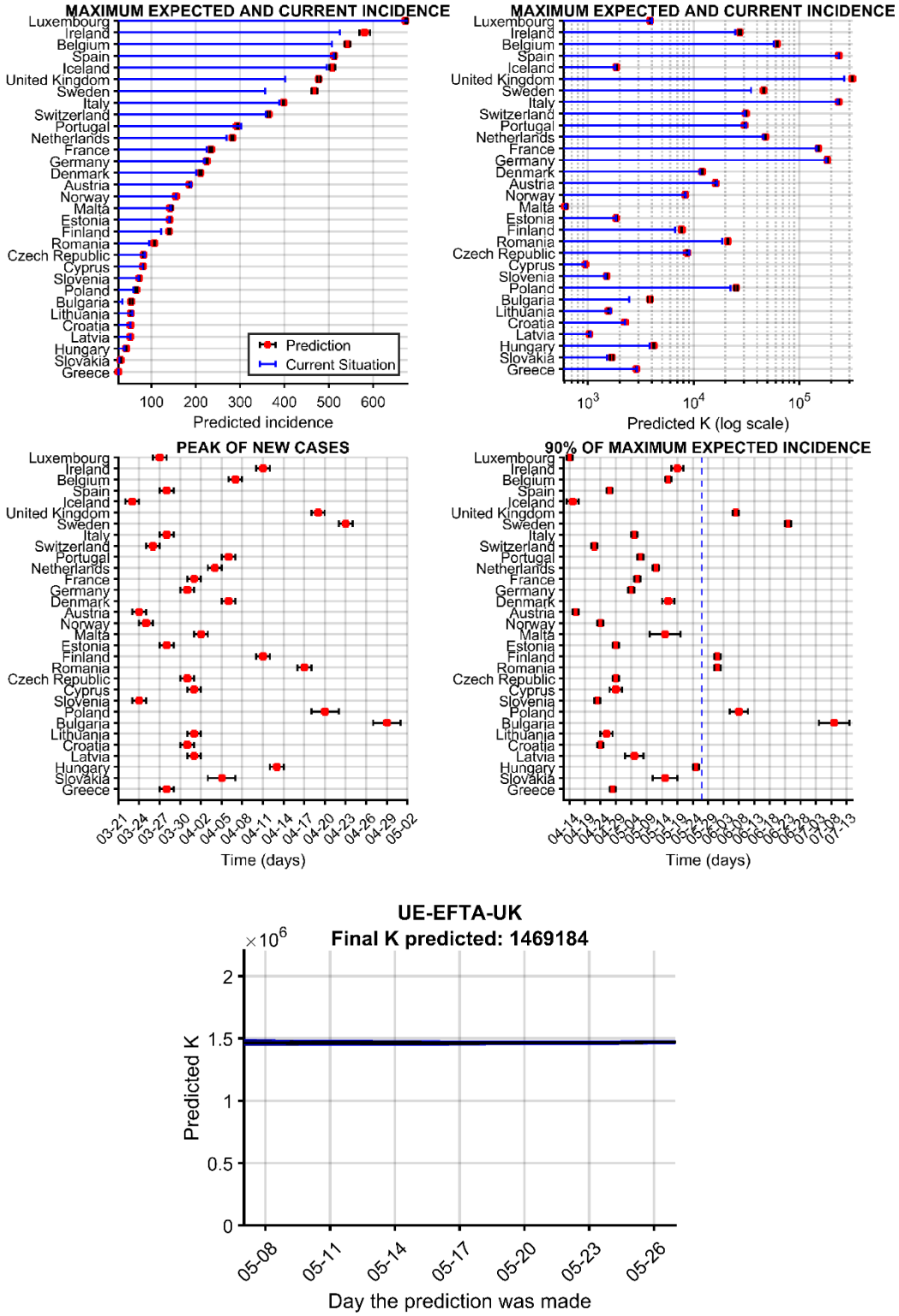
Countries	Days since the first 100 cases	Time interval between 1 and 10 cases / 10^5 inh. (days)	Time interval between 10 and 100 cases / 10^5 inh. (days)
Italy	95	11	16
Germany	89	12	17
France	88	10	20
Spain	88	8	12
United Kingdom	84	10	12
Belgium	83	11	14
Netherlands	83	11	20
Sweden	83	10	28
Norway	83	2	7
Switzerland	83	8	11
Austria	81	10	14
Denmark	80	4	30
Czech Republic	77	11	NA
Finland	77	12	46
Greece	77	18	NA
Iceland	77	5	15
Portugal	76	9	15
Slovenia	76	6	NA
Estonia	75	5	30
Ireland	75	8	18
Poland	75	17	NA
Romania	75	15	NA
Luxembourg	72	6	7
Slovakia	71	24	NA
Bulgaria	70	30	NA
Croatia	70	12	NA
Hungary	69	20	NA
Latvia	69	12	NA
Lithuania	68	9	NA
Malta	67	9	35
Cyprus	66	12	NA

Other countries

Countries	Days since the first 100 cases	Time interval between 1 and 10 cases / 10^5 inh. (days)	Time interval between 10 and 100 cases / 10^5 inh. (days)
Iran	92	11	42
United States of America	87	8	15
Canada	78	11	27
Qatar	78	3	31
Brazil	75	20	34
Saudi Arabia	74	21	29
Chile	73	13	36
Pakistan	73	35	NA
India	73	38	NA
Russia	72	15	24
Peru	72	18	22
Ecuador	72	10	30
Mexico	71	25	NA
Argentina	70	39	NA
Belarus	59	10	18

Long-term predictions

Evaluated with the **whole historical series**. See figure in the next page. Up-left: Predictions of maximum incidences per country (total final expected attack rate per 10^5 inh.). Up-right: Predictions of maximum absolute number of cases per country (K, in log scale). Blue lines indicate current situation. Bottom-left: Time in which peak in new cases was achieved / will be achieved. Bottom-right: Time at which 90 % of K was achieved / will be achieved. Blue dotted line indicates current date. At the end, predicted K for whole EU+EFTA+UK.



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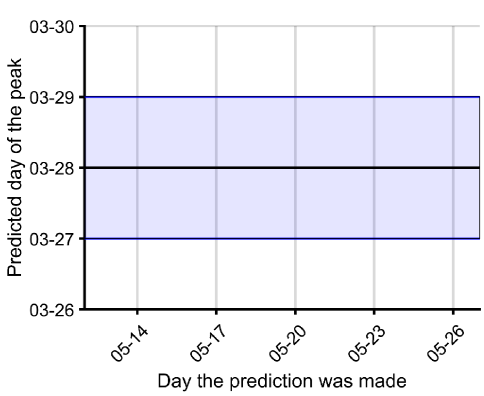
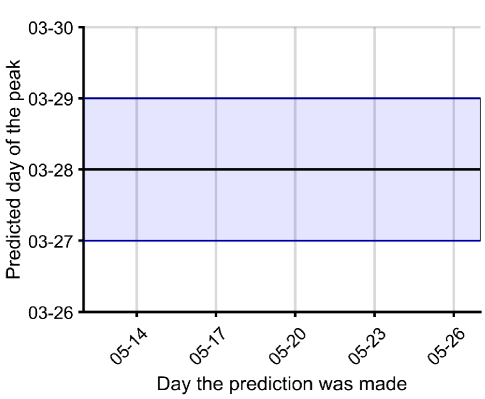

Predicted day of the peak
03-30
03-29
03-28
03-27
03-26
05-14
05-17
05-20
05-23
05-26
Day the prediction was made

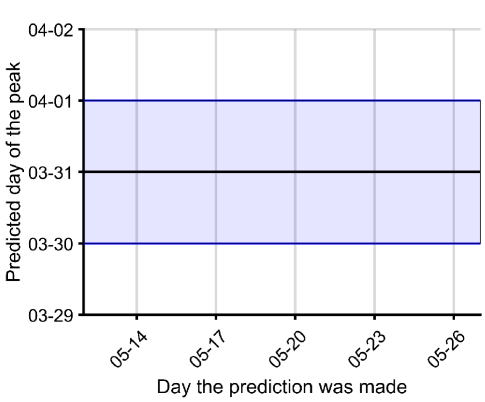
Spain
Predicted day for 90% of K
04-29
04-28
04-27
04-26
04-25
04-24
05-14
05-17
05-20
05-23
05-26
Day the prediction was made

×10^5
Predicted K
3.5
3
2.5
2
1.5
1
0.5
0
05-14
05-17
05-20
05-23
05-26
Day the prediction was made


Predicted day of the peak
03-30
03-29
03-28
03-27
03-26
05-14
05-17
05-20
05-23
05-26
Day the prediction was made

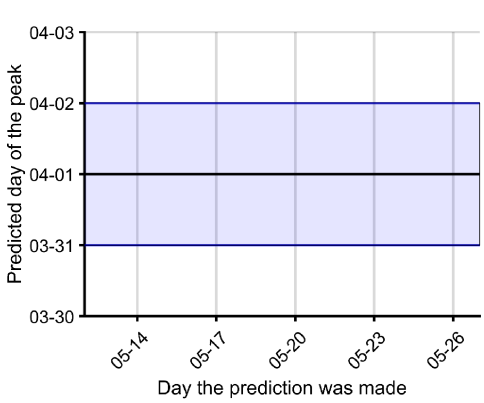
Italy
Predicted day for 90% of K
05-07
05-06
05-05
05-04
05-03
05-02
05-14
05-17
05-20
05-23
05-26
Day the prediction was made

×10^5
Predicted K
3.5
3
2.5
2
1.5
1
0.5
0
05-14
05-17
05-20
05-23
05-26
Day the prediction was made


Predicted day of the peak
04-02
04-01
03-31
03-30
03-29
05-14
05-17
05-20
05-23
05-26
Day the prediction was made

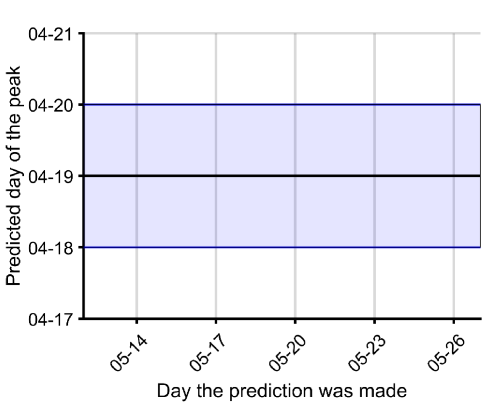
Germany
Predicted day for 90% of K
05-07
05-06
05-05
05-04
05-03
05-02
05-01
05-14
05-17
05-20
05-23
05-26
Day the prediction was made

×10^5
Predicted K
2.5
2
1.5
1
0.5
0
05-14
05-17
05-20
05-23
05-26
Day the prediction was made


Predicted day of the peak
04-03
04-02
04-01
03-31
03-30
05-14
05-17
05-20
05-23
05-26
Day the prediction was made

France
Predicted day for 90% of K
05-10
05-09
05-08
05-07
05-06
05-05
05-04
05-14
05-17
05-20
05-23
05-26
Day the prediction was made

×10^5
Predicted K
2
1.5
1
0.5
0
05-14
05-17
05-20
05-23
05-26
Day the prediction was made


Predicted day of the peak
04-21
04-20
04-19
04-18
04-17
05-14
05-17
05-20
05-23
05-26
Day the prediction was made

United Kingdom
Predicted day for 90% of K
06-09
06-08
06-07
06-06
06-05
05-14
05-17
05-20
05-23
05-26
Day the prediction was made

×10^5
Predicted K
4
3
2
1
0
05-14
05-17
05-20
05-23
05-26
Day the prediction was made

Situation and trends in Italian regions[1]

Situation and trends

	Reported data								Indexes		
Country	Cumulative cases	Attack rate /10^5 inh.	Cumulative deaths	Mortality /10^5 inh.	Active cases (last 14 days)	14-day attack rate /10^5 inh.	Estimated active cases (last 14 days)	Estimated 14-day attack rate /10^5 inh.	ρ_7 [(1)]	EPG_{REP} [(2)]	EPG_{EST} [(3)]
Lombardia	88.183	878,2	15.974	159,1	4.363	43,4	81.173	806,8	0,89	39	720
Piemonte	30.445	698,9	3.838	88,1	1.236	28,4	15.802	362,8	0,73	21	265
Emilia Romagna	27.701	621,2	4.094	91,8	645	14,5	9.648	216,4	0,81	12	175
Veneto	19.125	389,8	1.898	38,7	280	5,7	2.774	56,5	0,57	3	32
Toscana	10.086	270,4	1.029	27,6	227	6,1	2.364	63,4	0,69	4	44
Liguria	9.605	619,4	1.445	93,2	610	39,3	9.328	601,4	0,86	34	518
Lazio	7.693	130,9	708	12,0	402	6,8	3.747	63,7	0,62	4	40
Marche	6.719	440,5	997	65,4	116	7,6	1.717	112,6	0,75	6	85
Campania	4.777	82,3	410	7,1	138	2,4	1.178	20,3	0,74	2	15
Puglia	4.481	111,2	496	12,3	124	3,1	1.395	34,6	1,24	4	43
Trento	4.425	412,7	462	43,1	110	10,3	1.155	214,8	0,80	8	171
Sicilia	3.438	68,8	272	5,4	72	1,4	584	11,7	0,57	1	7
Friuli Venezia Giulia	3.262	268,4	333	27,4	101	8,3	1.020	84,0	0,91	8	77
Abruzzo	3.237	246,8	402	30,7	101	7,7	1.231	93,8	0,49	4	46
Bolzano	2.595	2.415,4	291	270,9	17	15,8	203	39,0	0,60	9	23
Umbria	1.431	162,2	75	8,5	11	1,2	NA	NA	0,51	1	NA
Sardegna	1.355	82,6	130	7,9	10	0,6	86	5,2	NA	NA	NA
Valle dAosta	1.182	941,0	143	113,8	16	12,7	186	148,0	1,18	15	175
Calabria	1.158	59,5	96	4,9	15	0,8	NA	NA	0,34	0	NA
Molise	435	142,3	22	7,2	32	10,5	NA	NA	0,60	6	NA
Basilicata	399	70,9	27	4,8	10	1,8	NA	NA	1,31	2	NA
	Scale										
	Worst	Worst	Worst	Worst	Worst	Worst	Worst	Worst	2,0	100	1000
	Best	Best	Best	Best	Best	Best	Best	Best	0,0	0	0

[(1)] ρ_7 is the average of 7 consecutive ρ, but can still fluctuate. [(2,3)] EPG stands for Effective Growth Potential. EPG_{REP} is obtained by multiplying attack rate of last 14 days per 10^5 inhabitants (i.e. density of cases) by ρ_7 (a value related with effective reproduction number and that, therefore, determines the dynamics for subsequent days). EPG_{EST} is obtained by multiplying estimated real attack rate of last 14 days per 10^5 inhabitants by ρ_7.

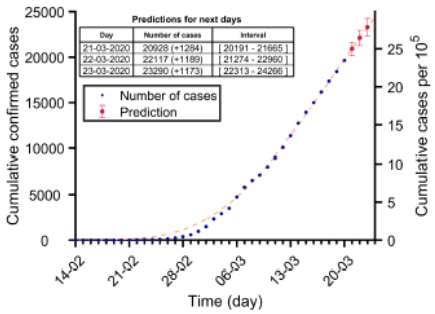
Disclaimer: estimated active cases and estimated 14-day attack rate are assessed by assuming a lethality of 1 % (see report from 20 to 24 April, #37-41). This value can change in countries where suspicious deaths are reported as well (real values would be lower) and in countries where incidence among elderly people was minor (real values would be higher).

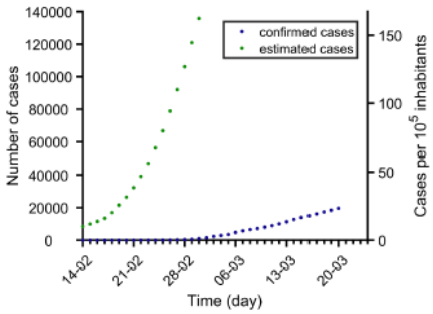
[1] **Spain:** Historical series have not been updated. Therefore, regional analysis is not shown

Legend: Countries' reports details

Iran 20-03-2020. Population: 83.7M. Current cumulated incidence: $23/10^5$

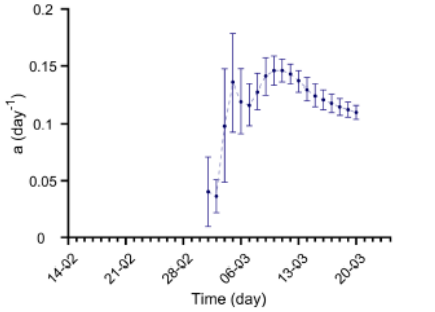
Confirmed cases: data (blue), model fitted (dashed line), predictions (red points and table)

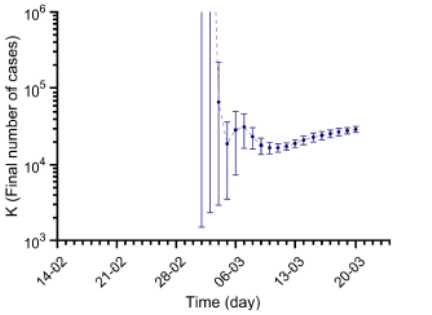




Estimated cases using death rate (see Methods)

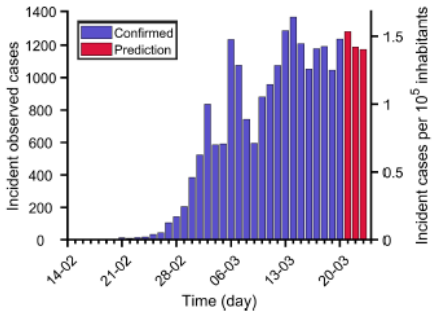
Fitted *a* value using points prior to each date

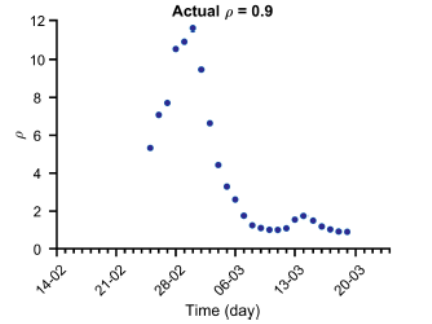




Fitted *K* value using points prior to each date

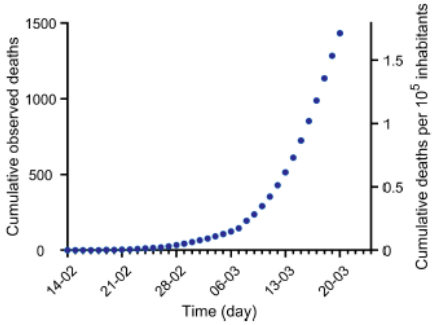
Reported and predicted new cases

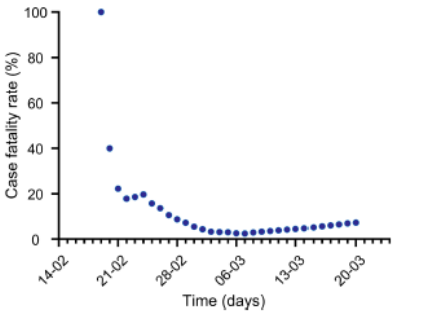




Evolution of ρ, a parameter related with Reproduction number (see Methods)

Reported deaths



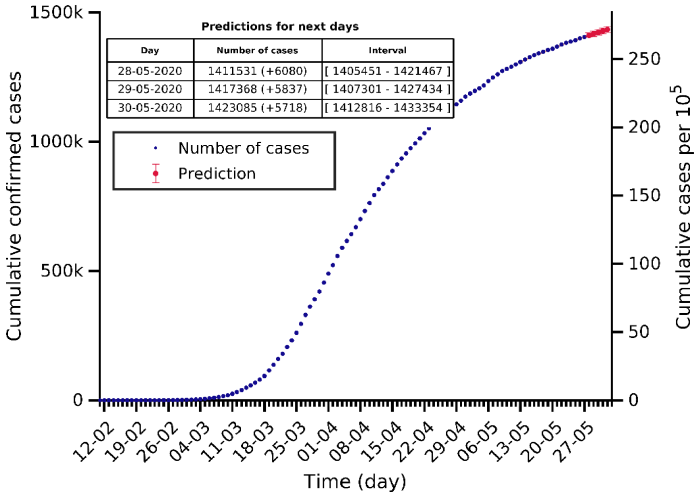


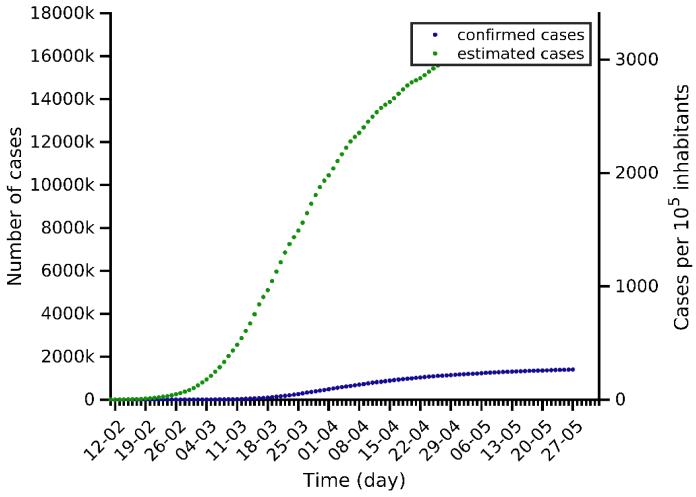
Deaths / cumulated reported cases

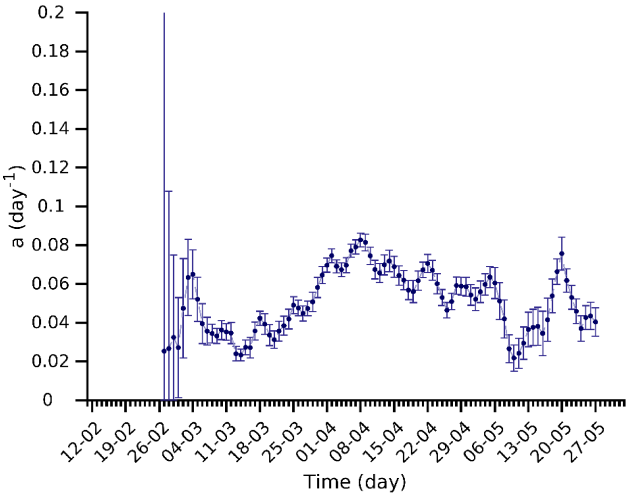
(1) Analysis and prediction of COVID-19 for EU+EFTA+UK

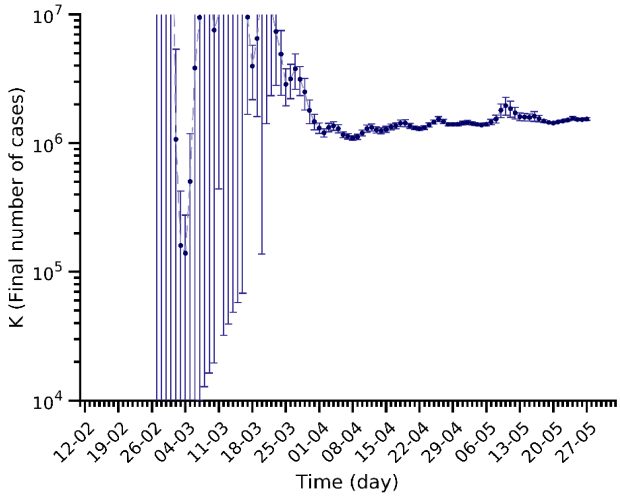
Data obtained from https://www.ecdc.europa.eu/en/geographical-distribution-2019-ncov-cases

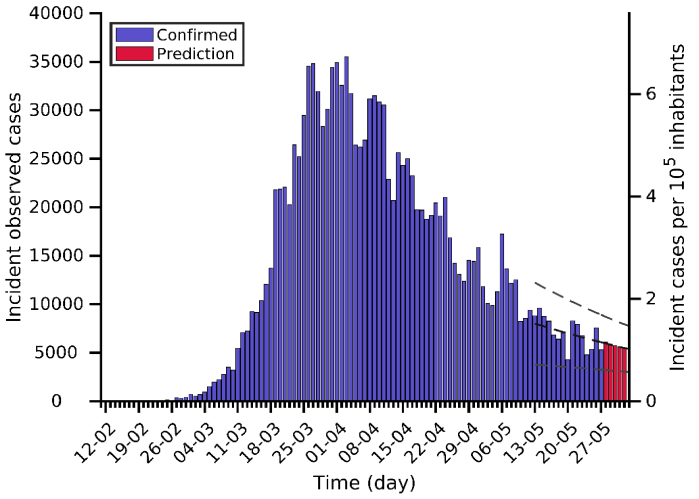
EU+EFTA+UK 27-05-2020. Population: 527.9M. Current cumulated incidence: 266/1

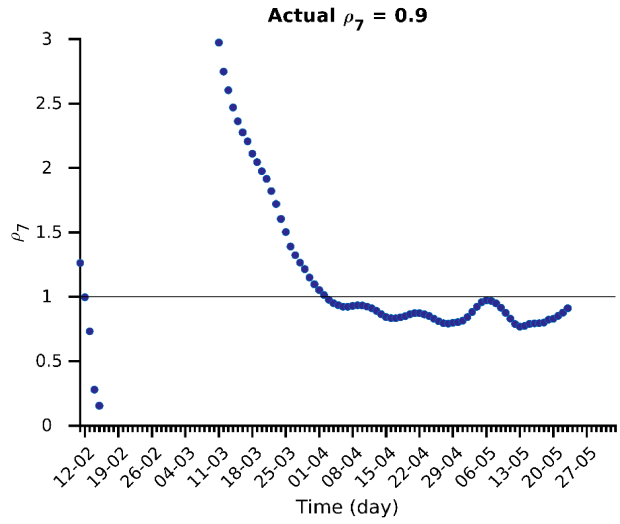


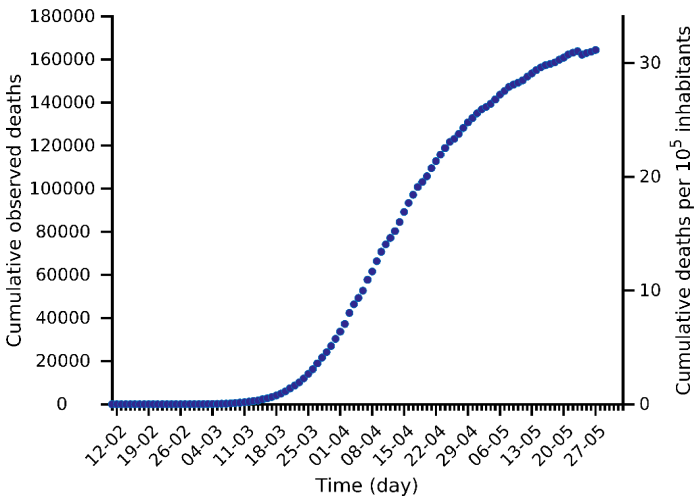


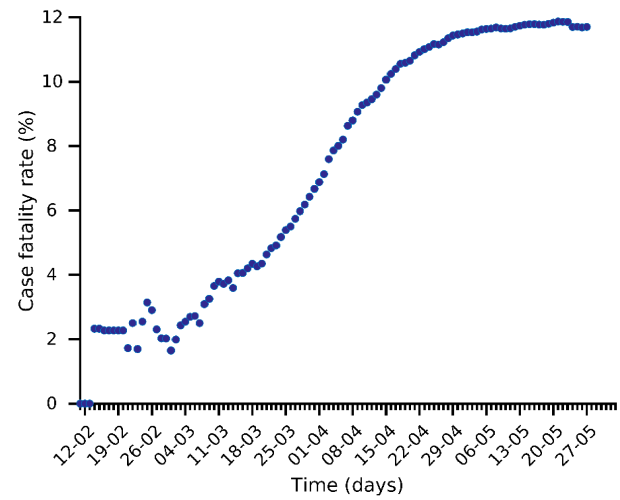




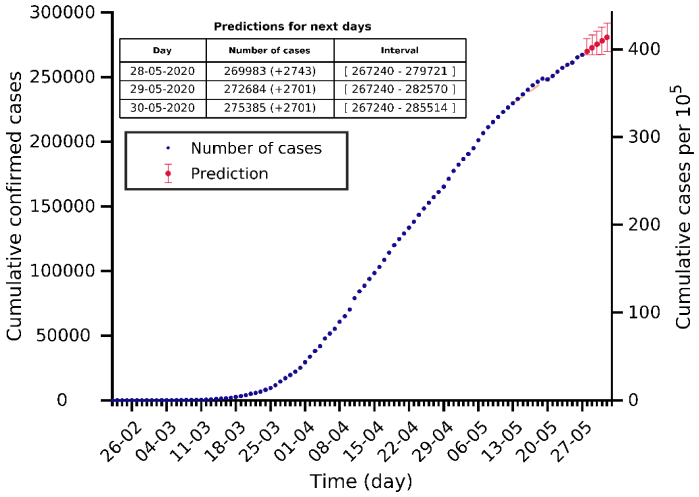


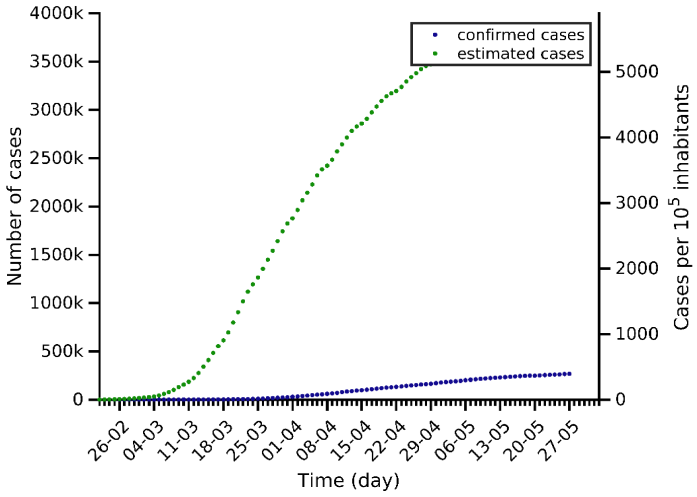


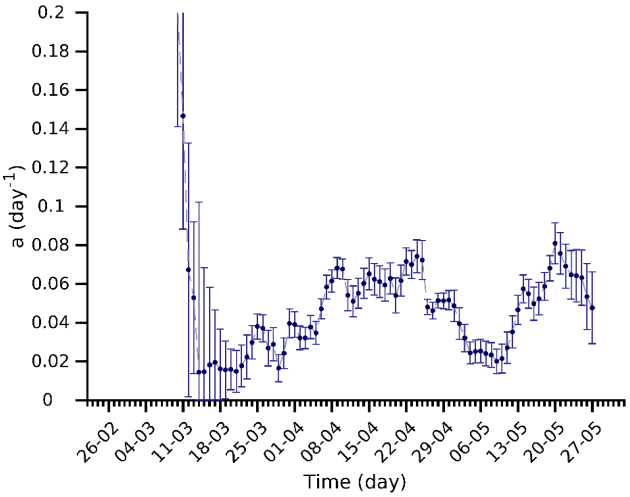


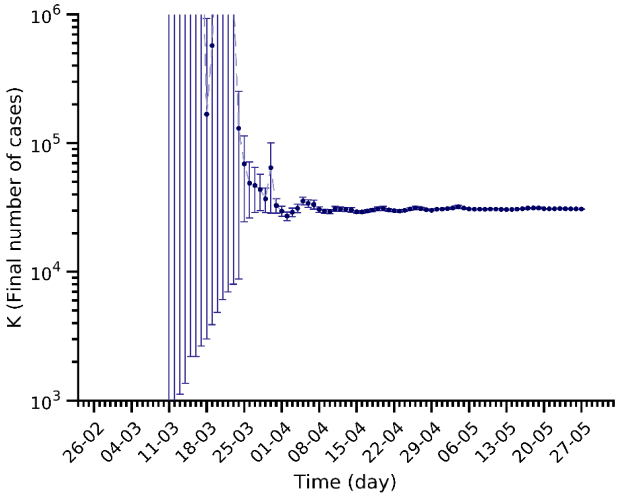


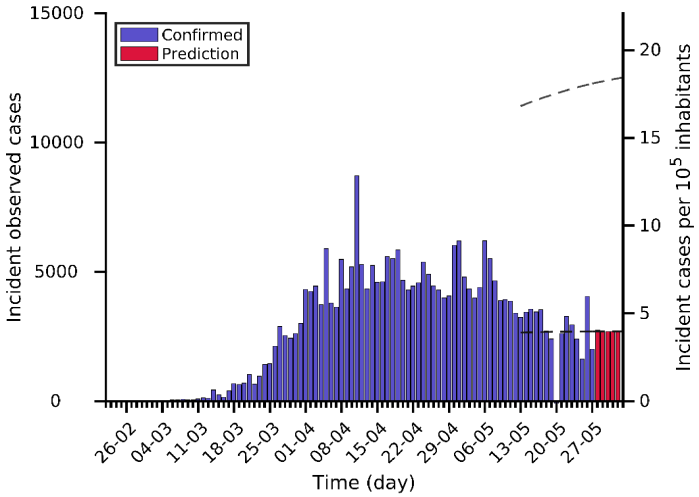
UK 27-05-2020. Population: 67.9M. Current cumulated incidence: 394/10^5

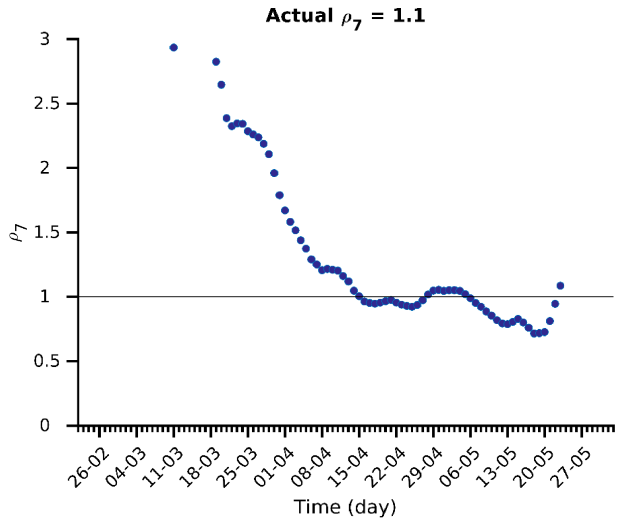


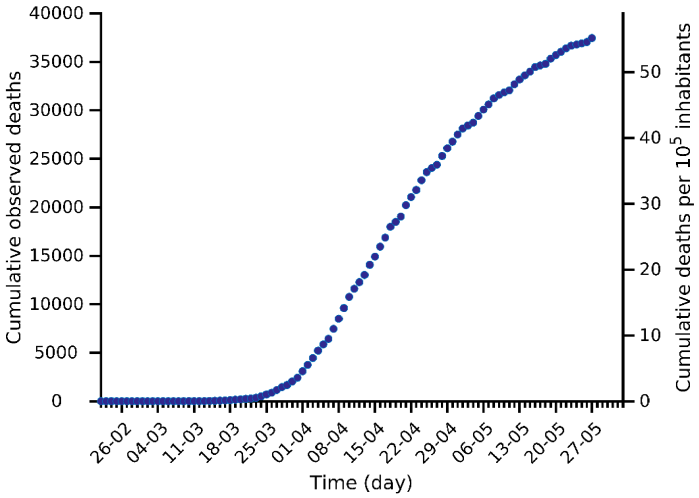


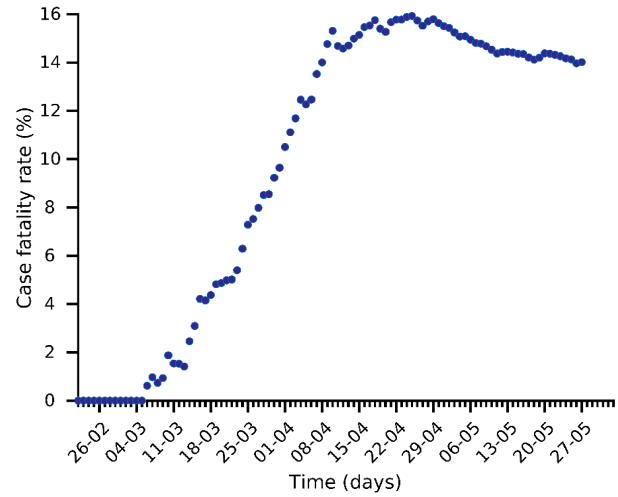




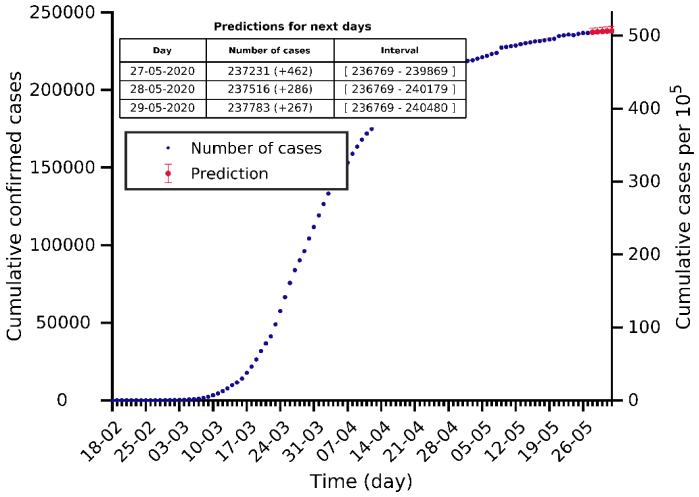


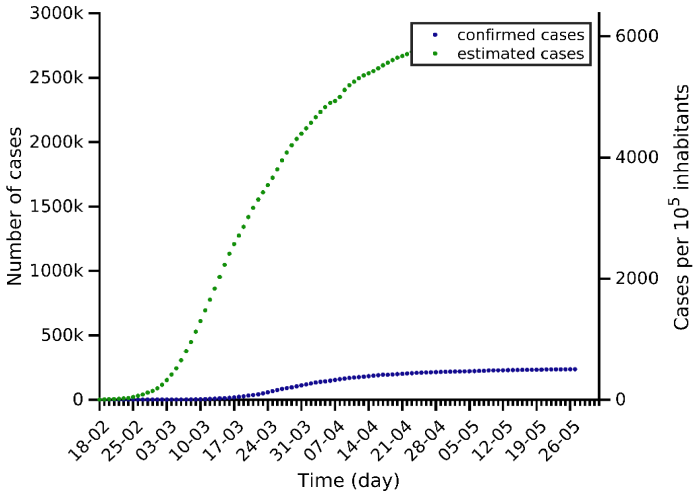


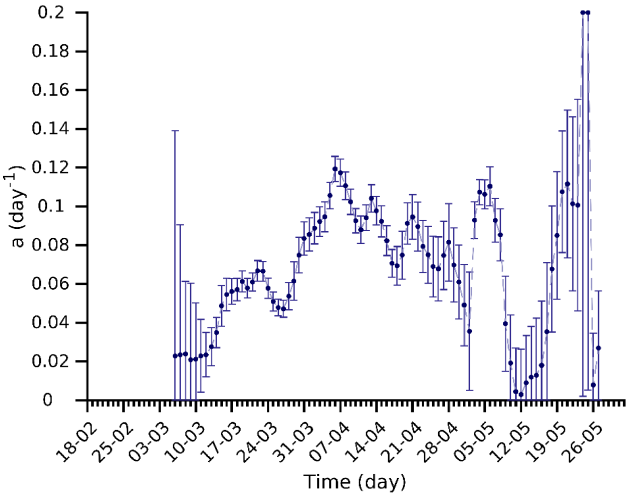


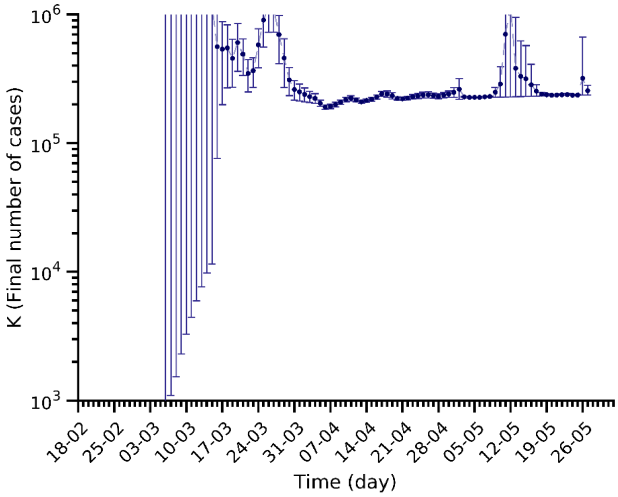


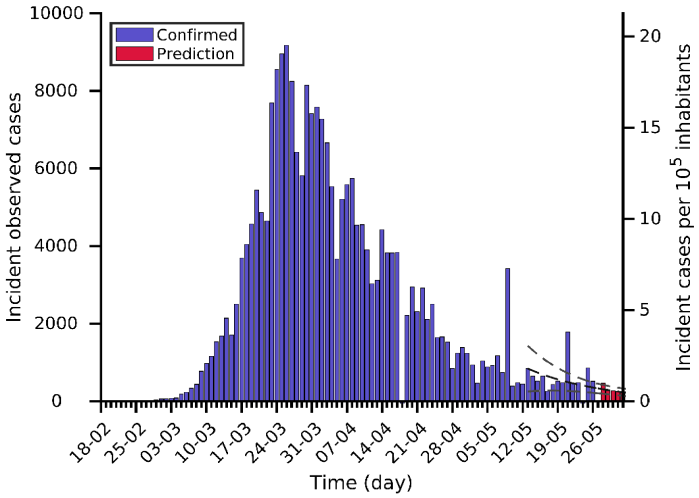
Spain 26-05-2020. Population: 47.0M. Current cumulated incidence: 503/10⁵

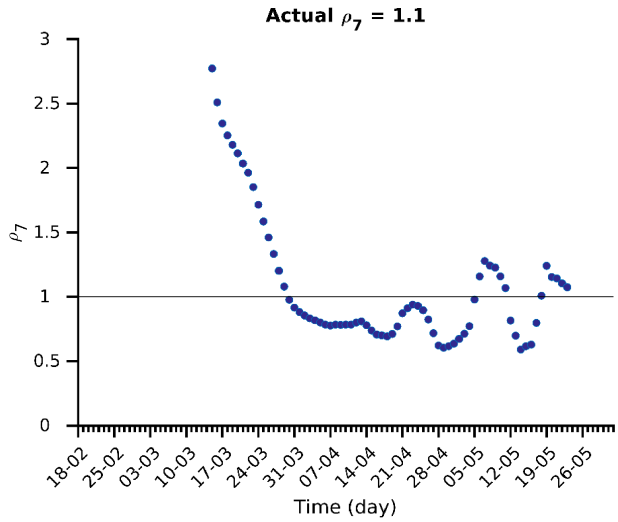


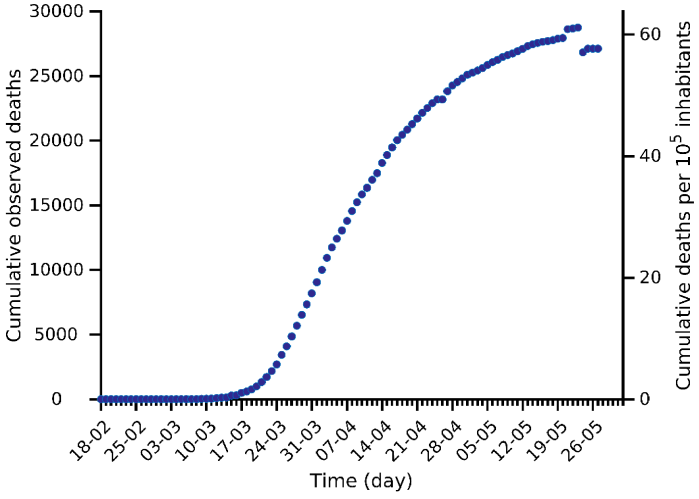


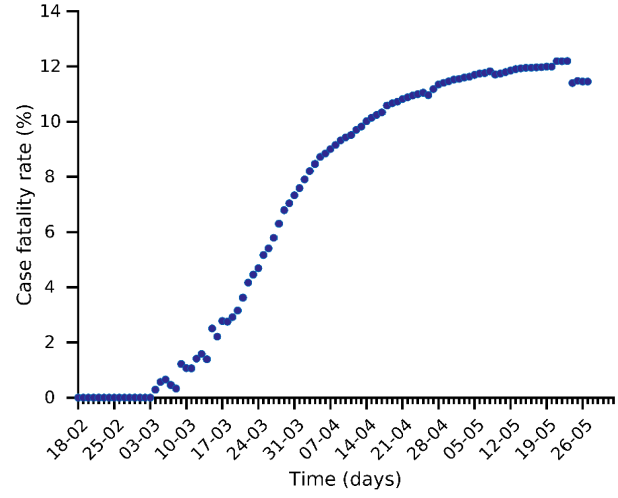




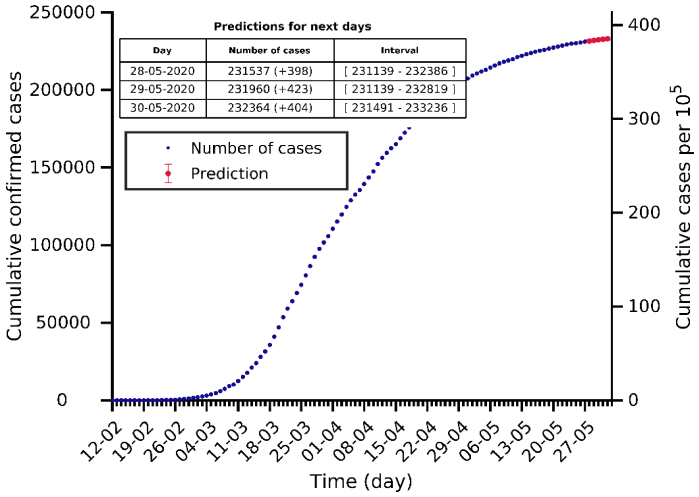


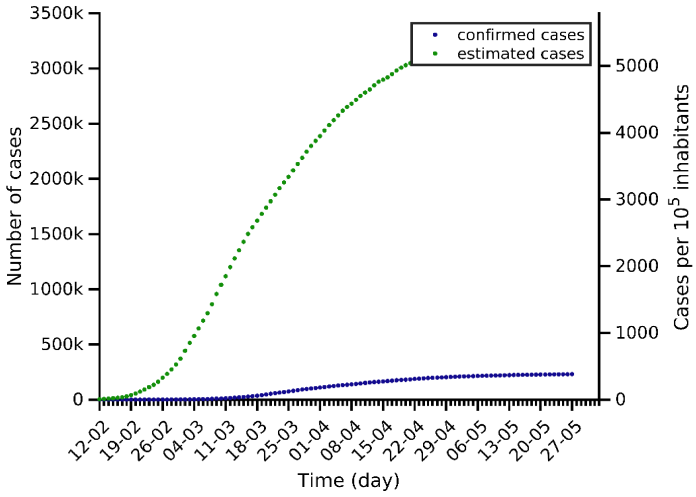


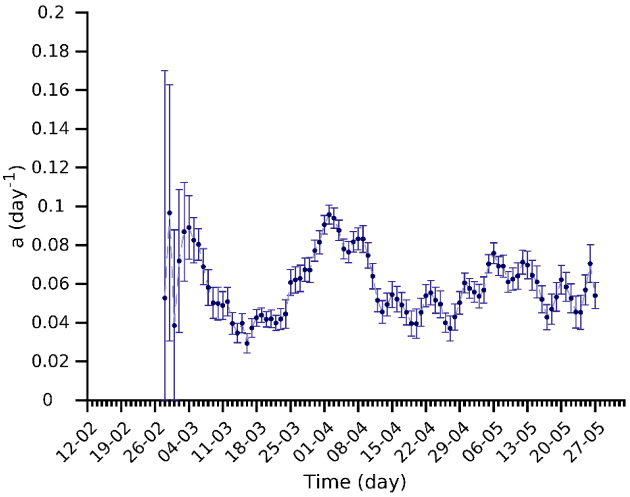


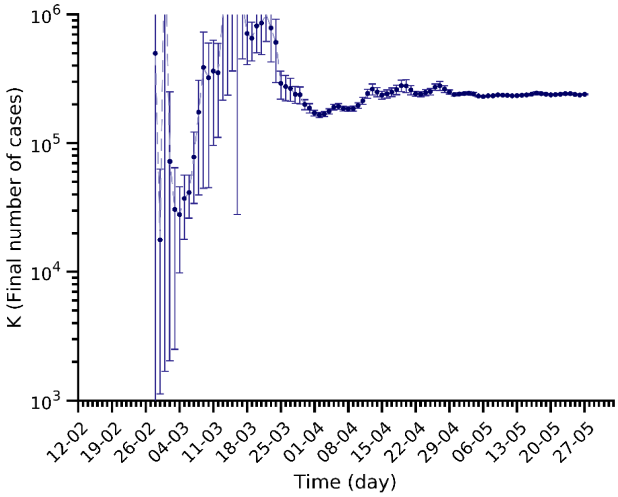


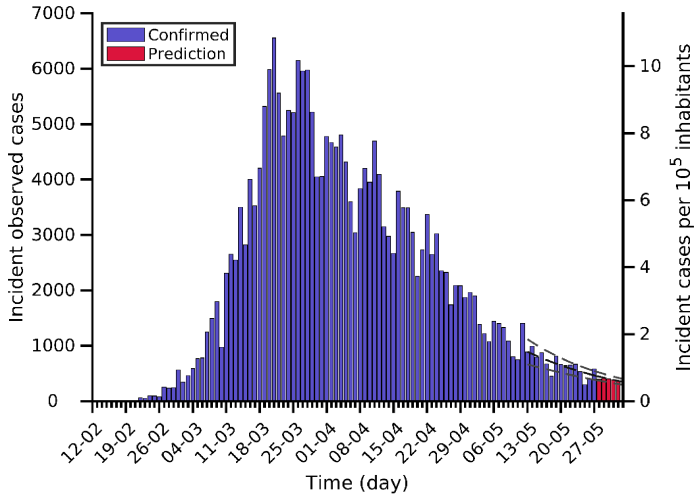
Italy 27-05-2020. Population: 60.5M. Current cumulated incidence: $382/10^5$

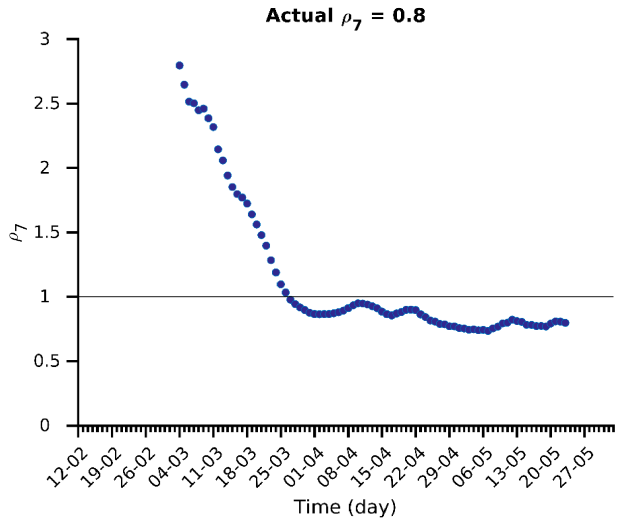


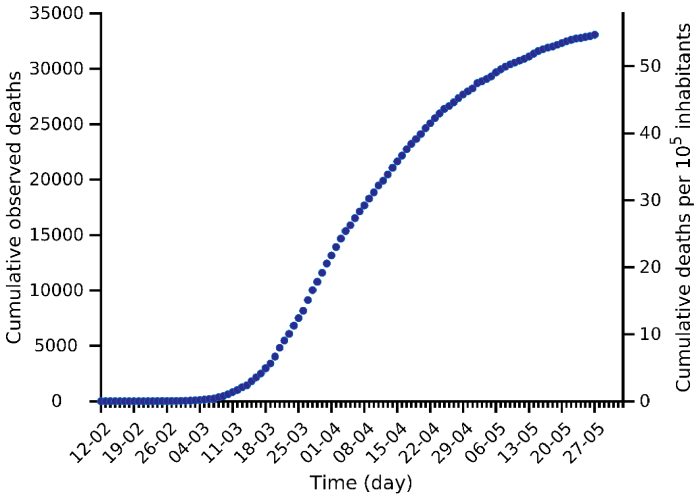


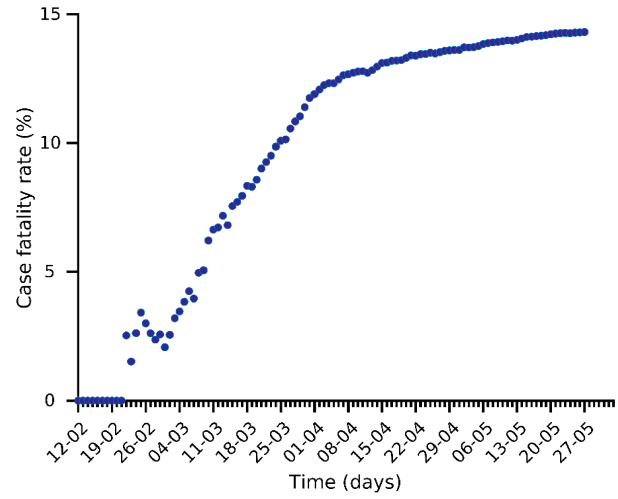




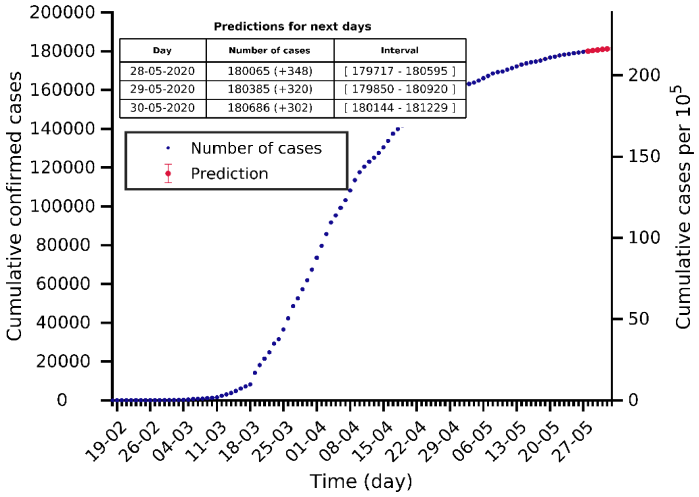


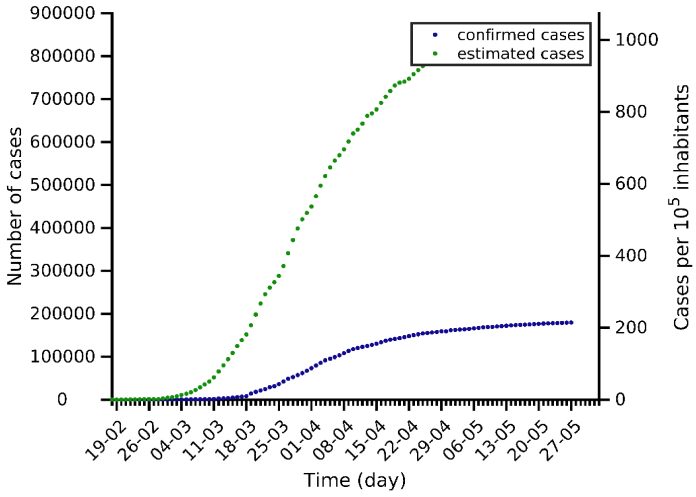


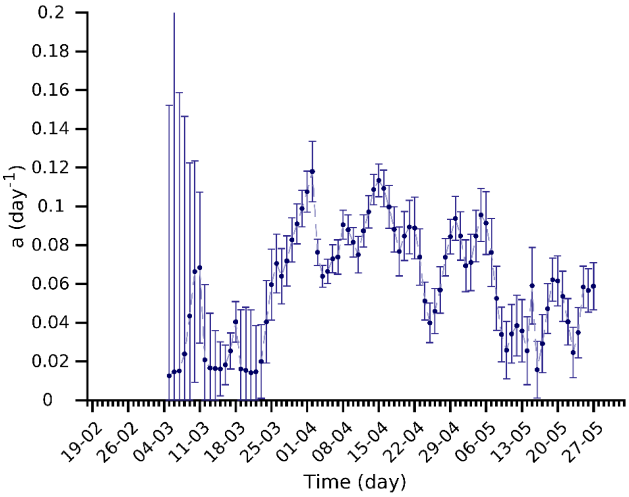


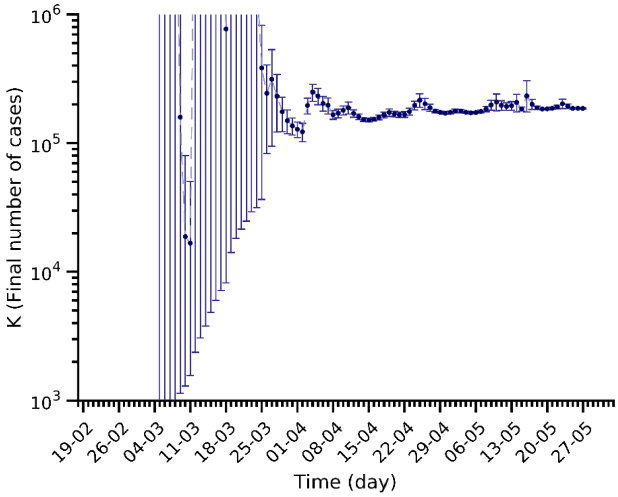


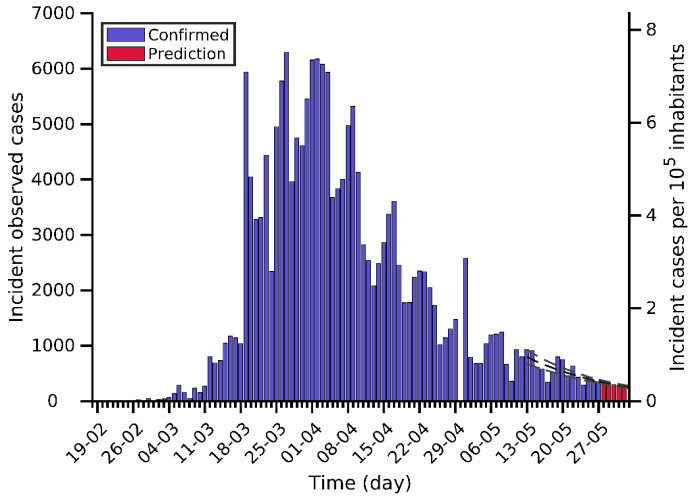
Germany 27-05-2020. Population: 83.8M. Current cumulated incidence: 215/10^5

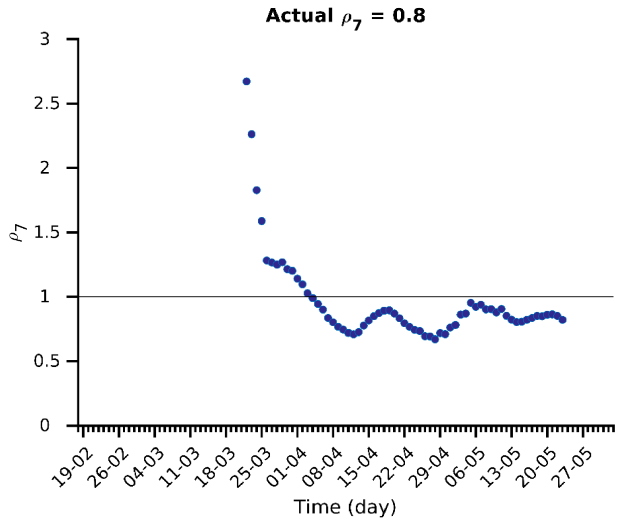


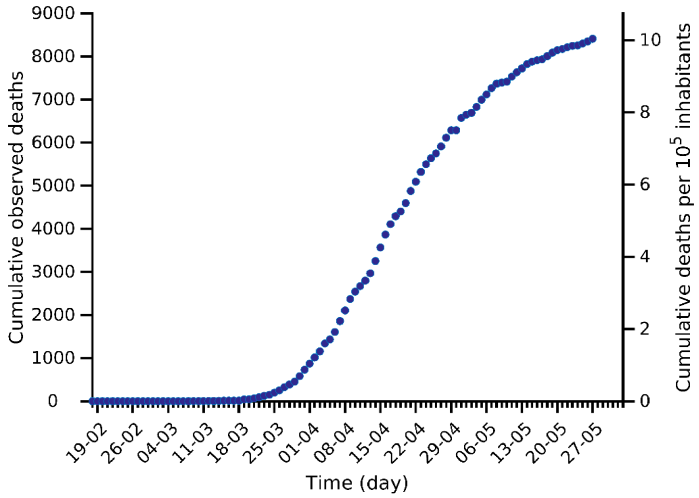


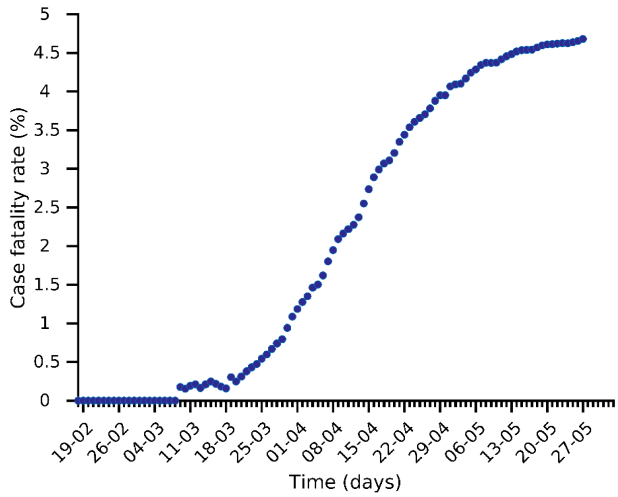




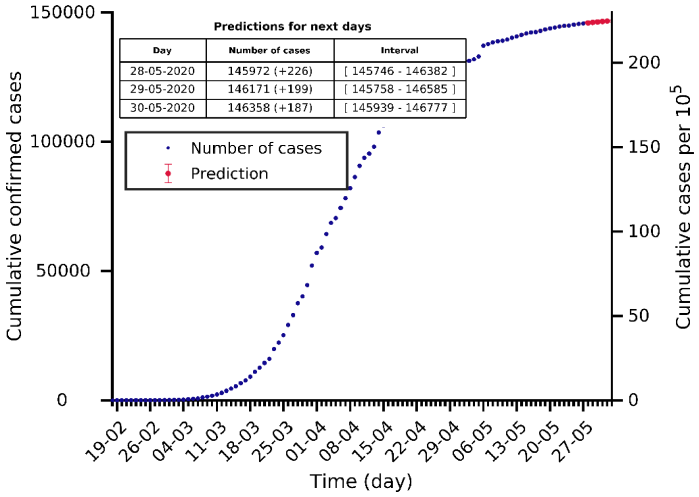


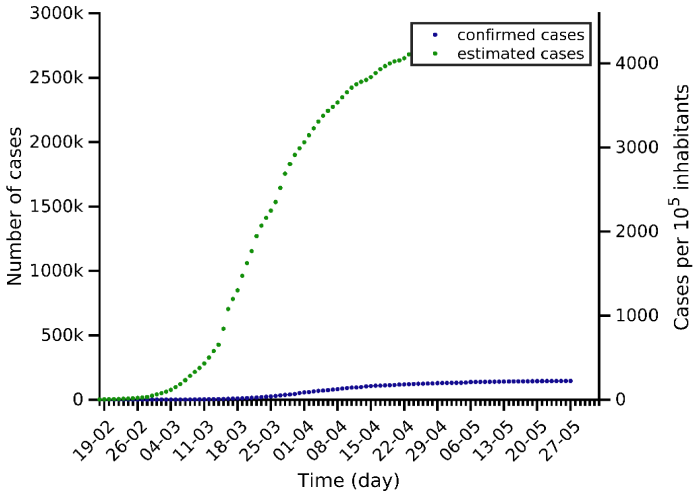


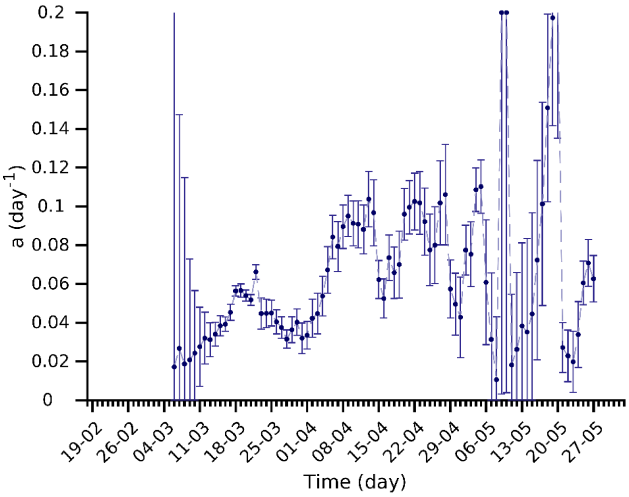


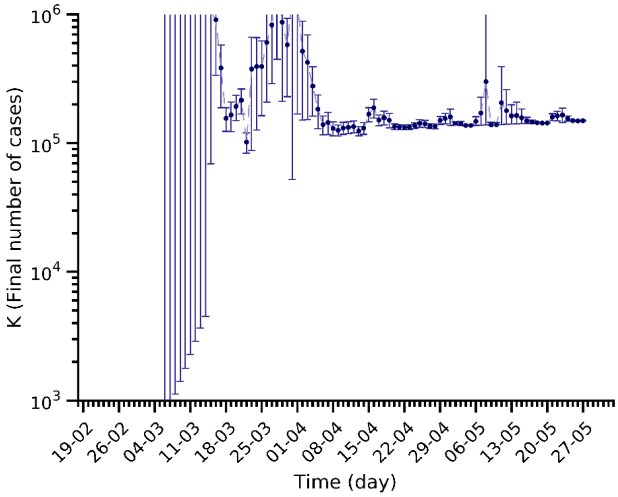


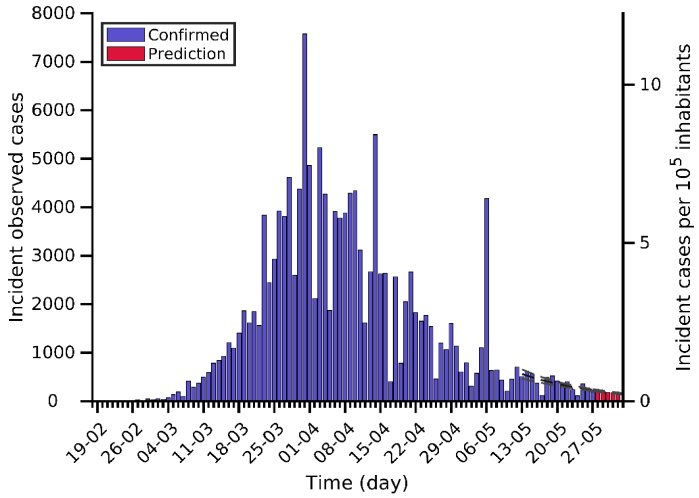
France 27-05-2020. Population: 65.3M. Current cumulated incidence: 223/10^5

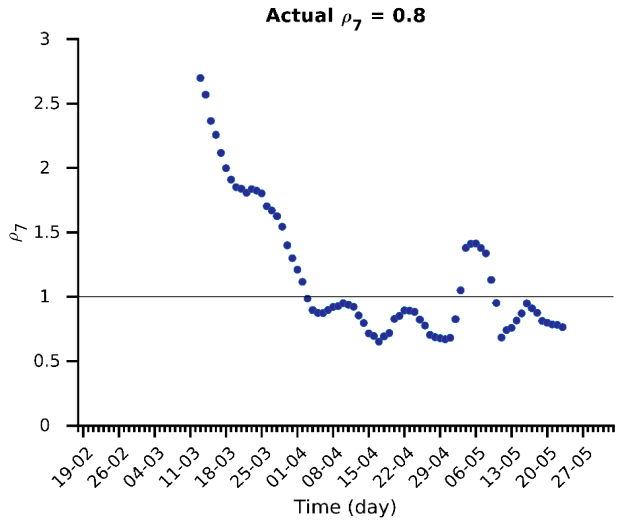


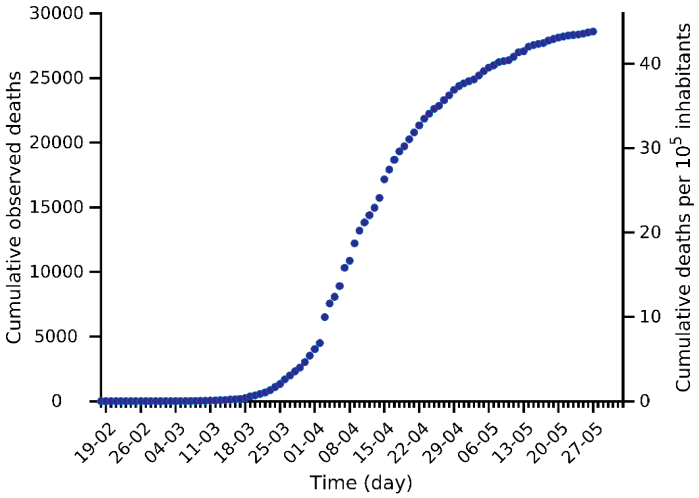


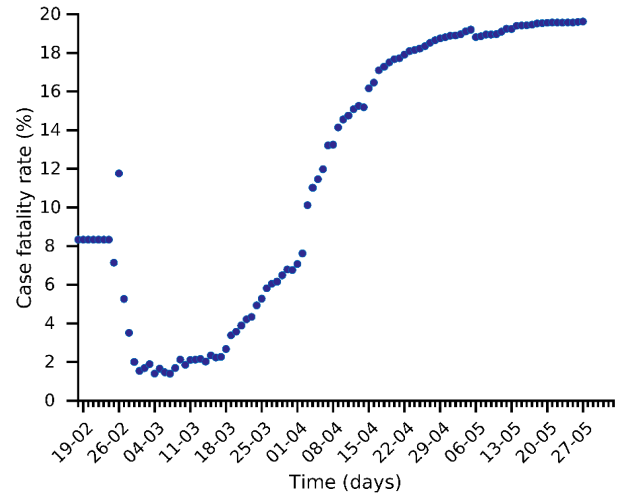




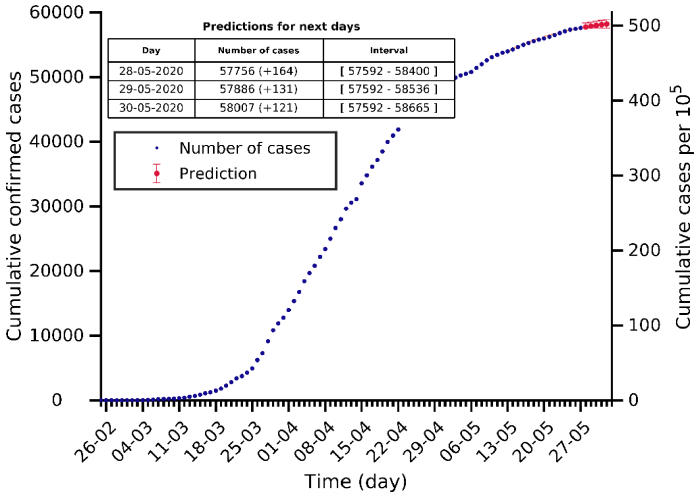


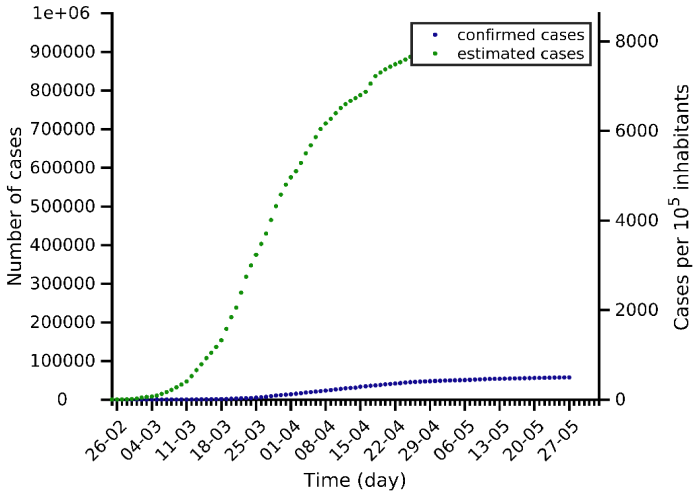


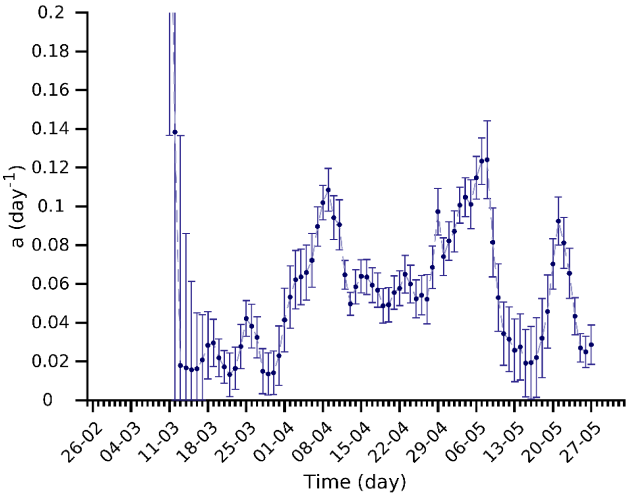


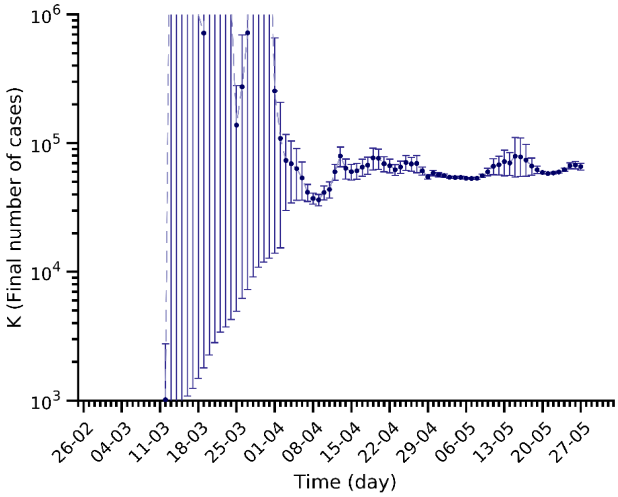


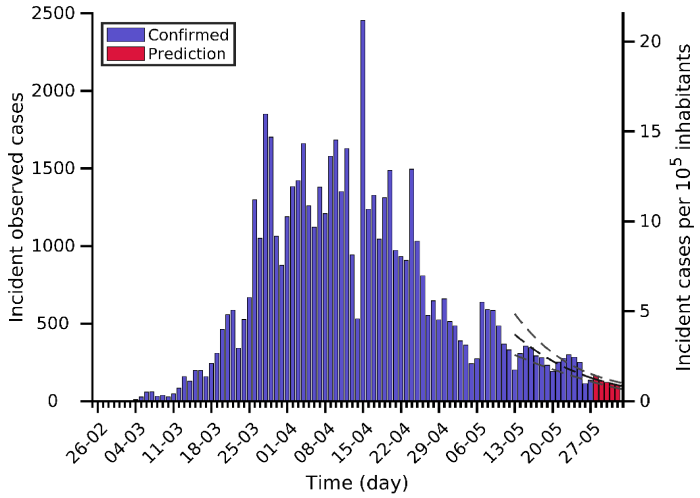
Belgium 27-05-2020. Population: 11.6M. Current cumulated incidence: 497/10^5

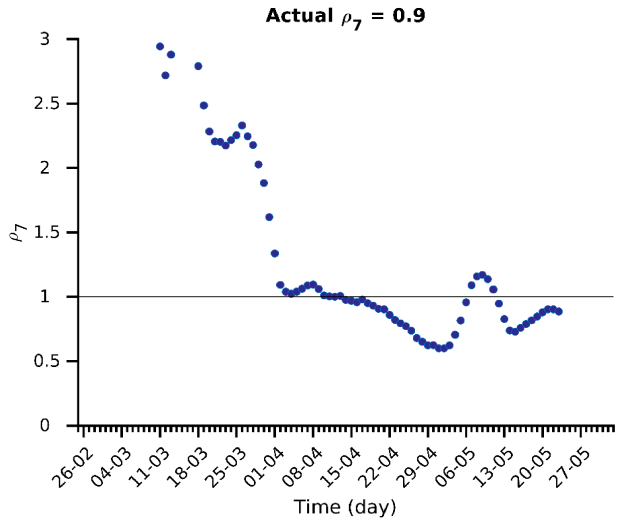


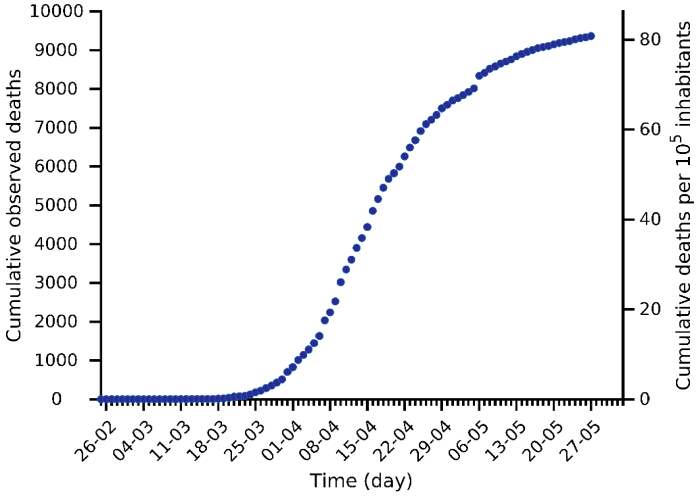


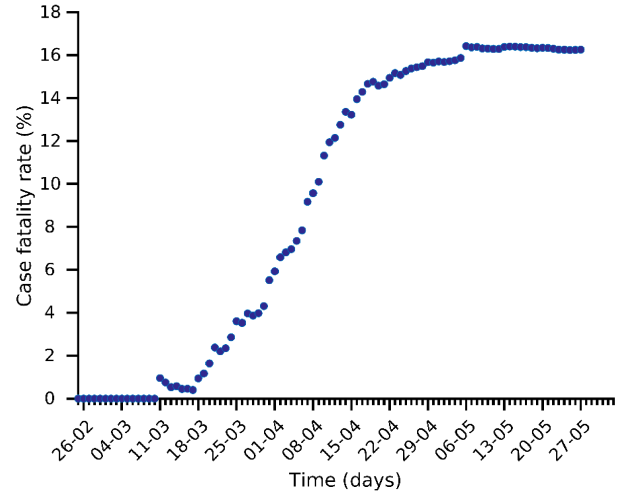




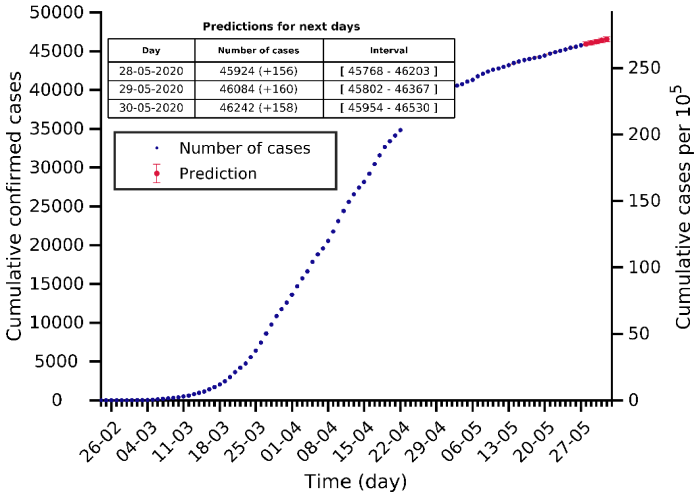


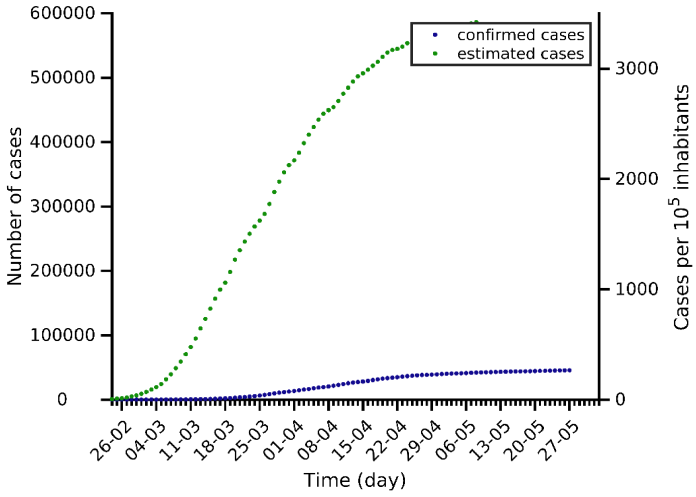


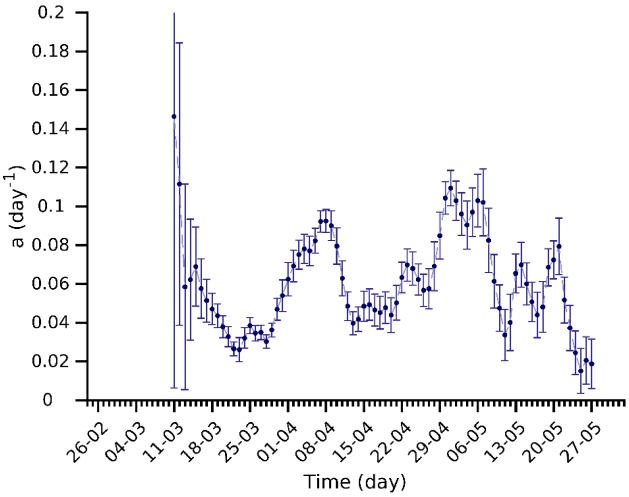


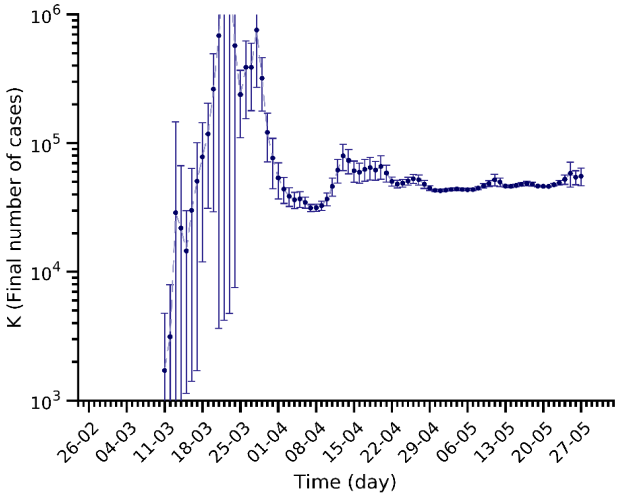


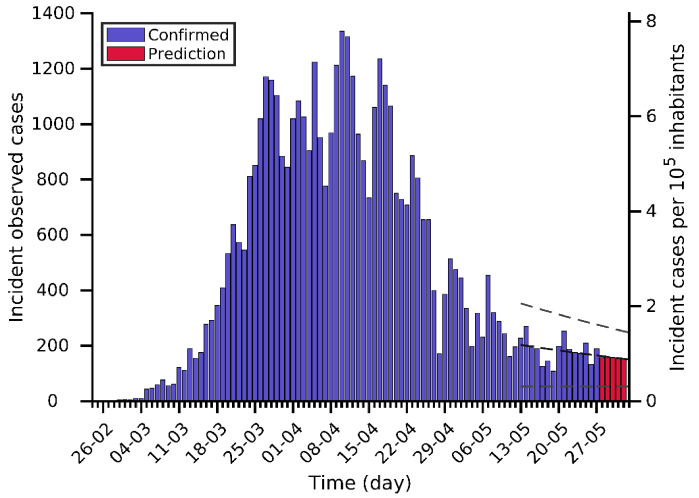
Netherlands 27-05-2020. Population: 17.1M. Current cumulated incidence: 267/10^5

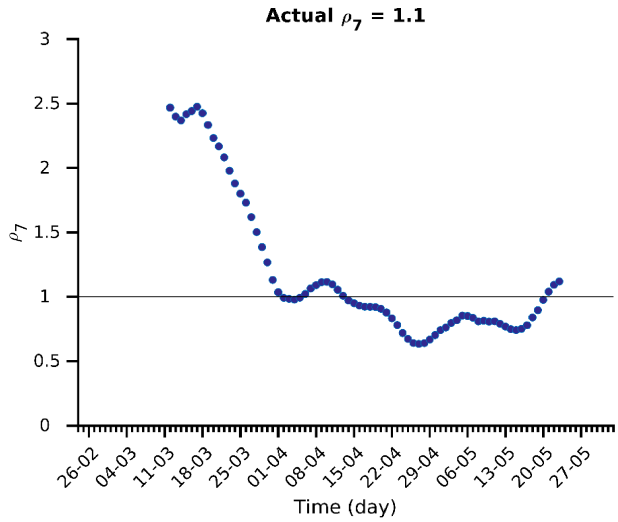


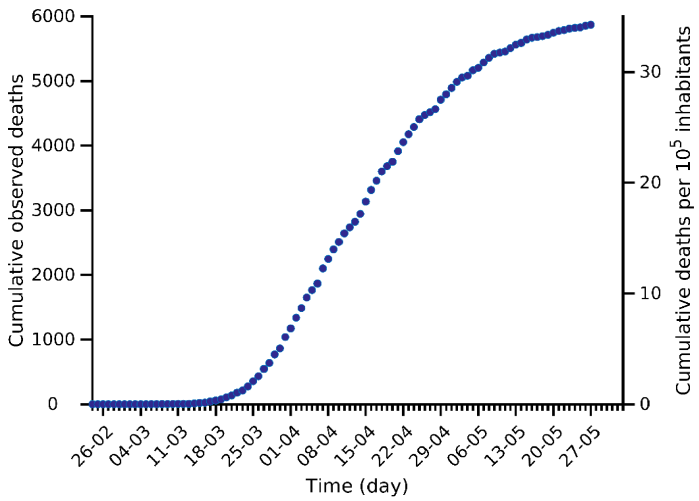


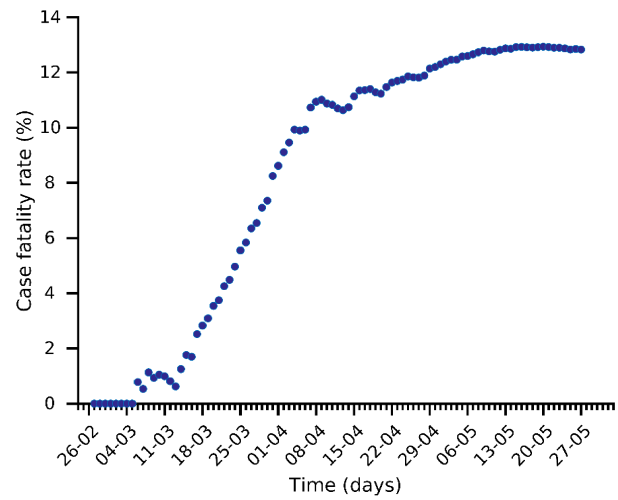




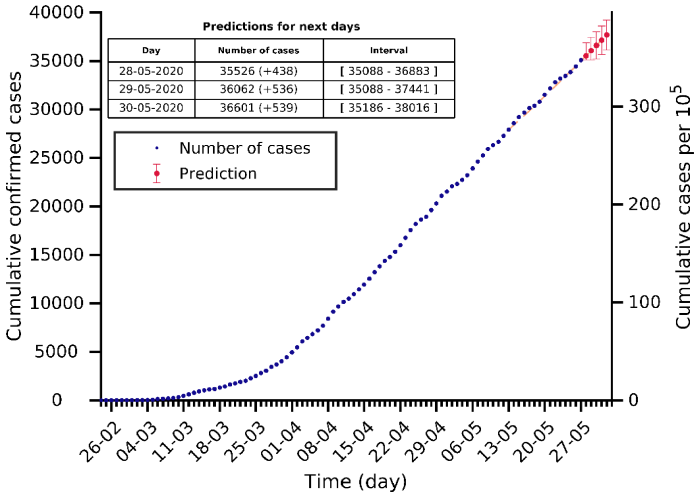


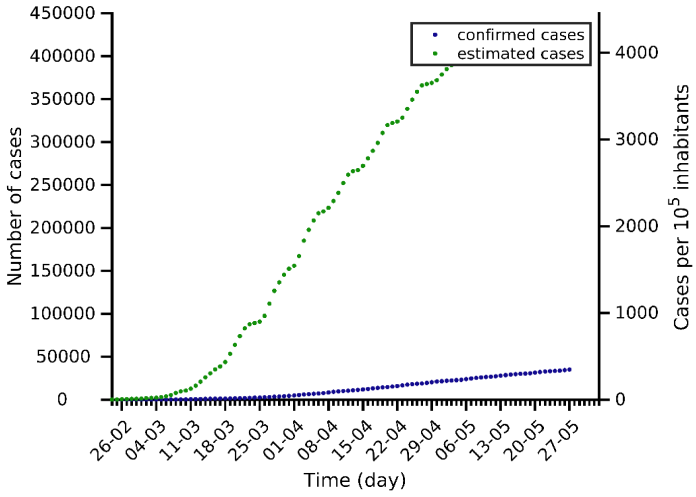


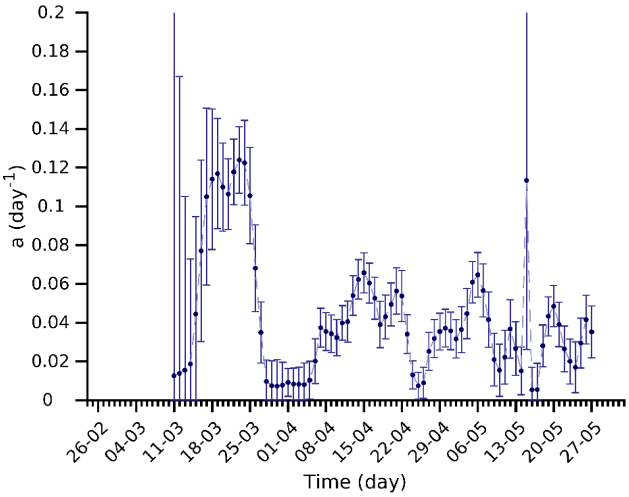


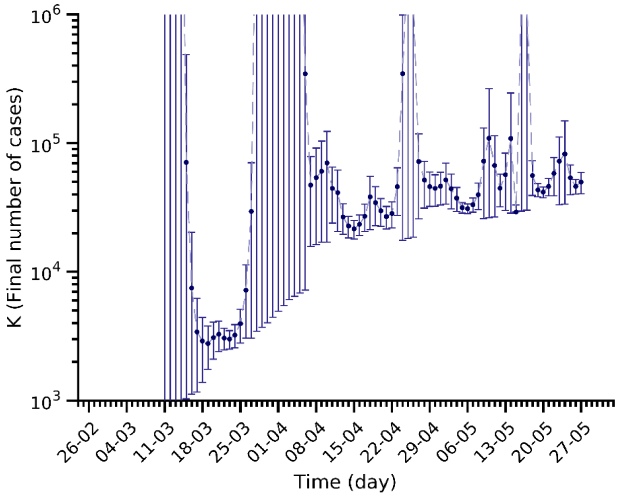


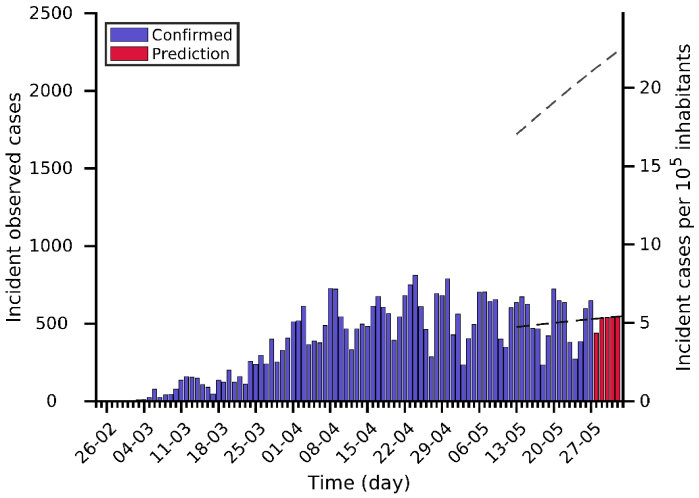
Sweden 27-05-2020. Population: 10.1M. Current cumulated incidence: 347/10⁵

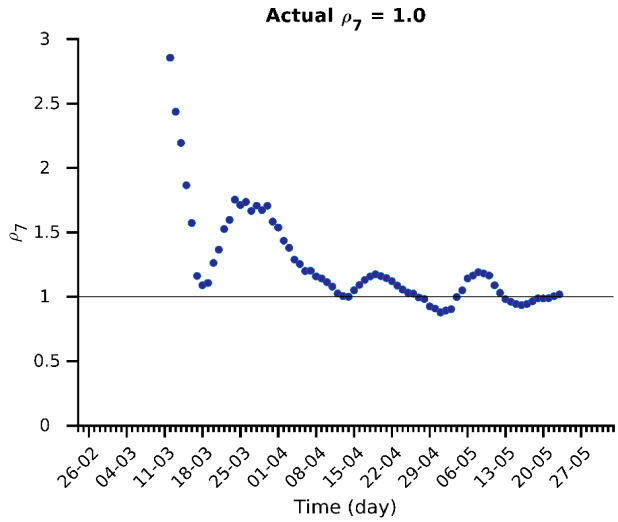


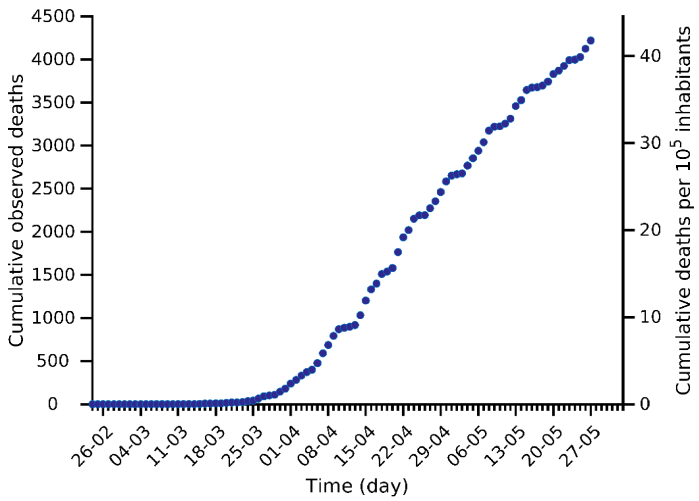


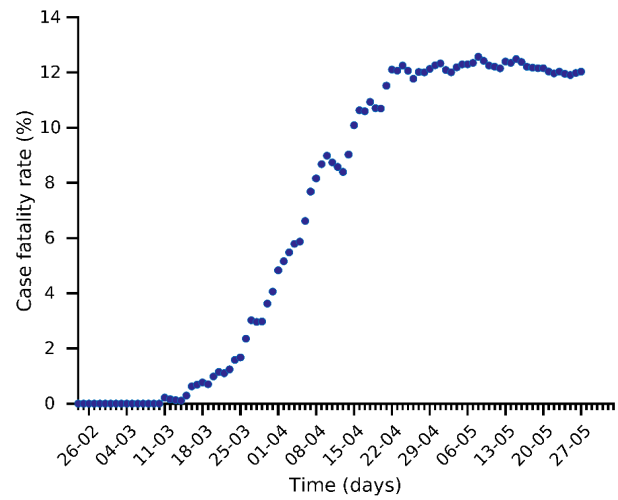




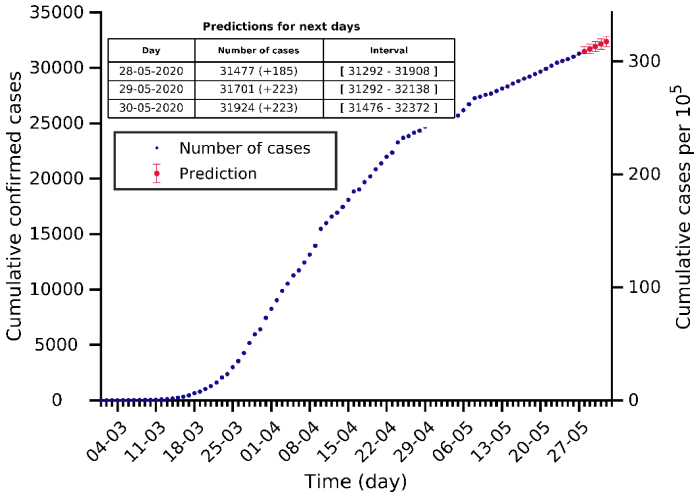


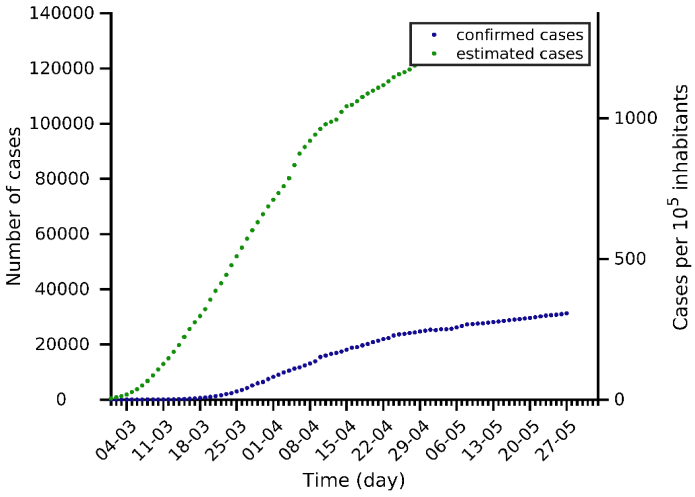


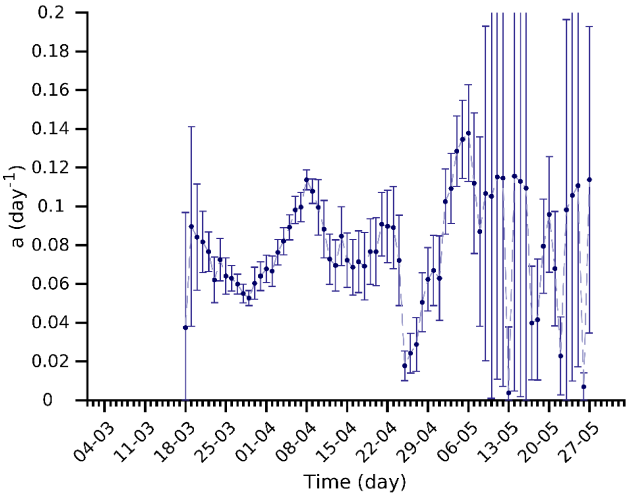


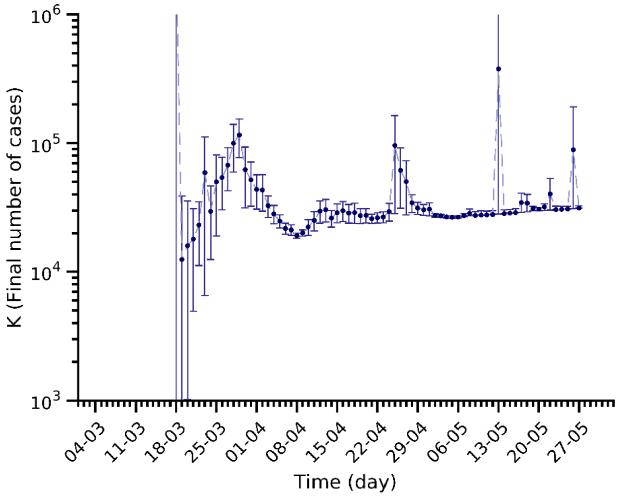


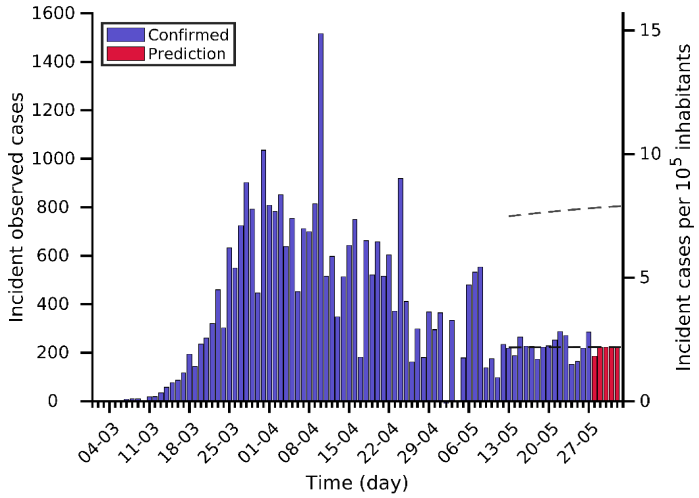
Portugal 27-05-2020. Population: 10.2M. Current cumulated incidence: 307/10⁵

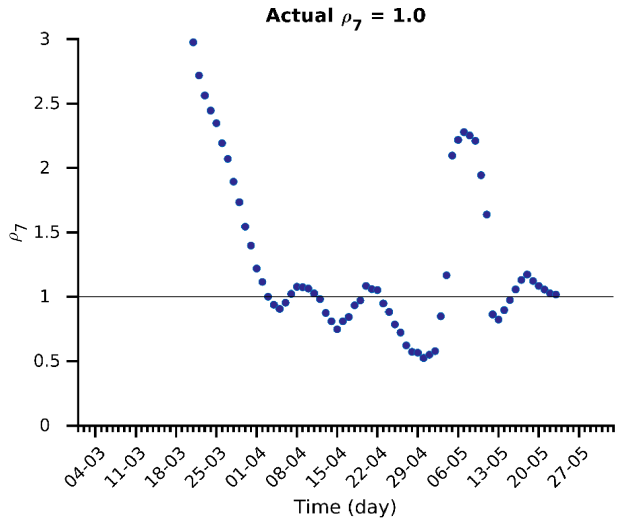


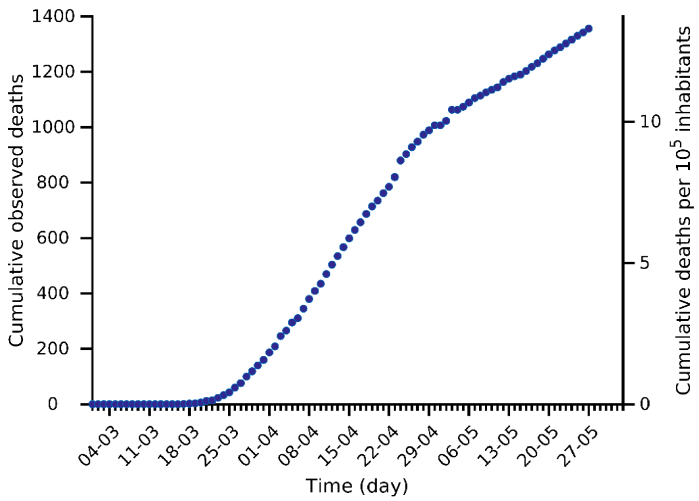


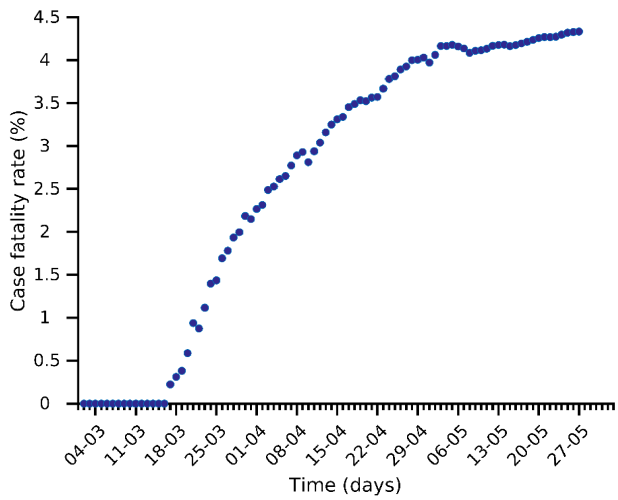




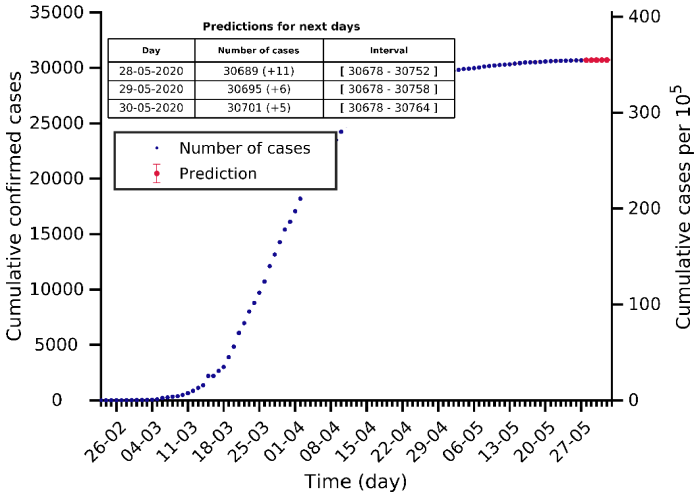


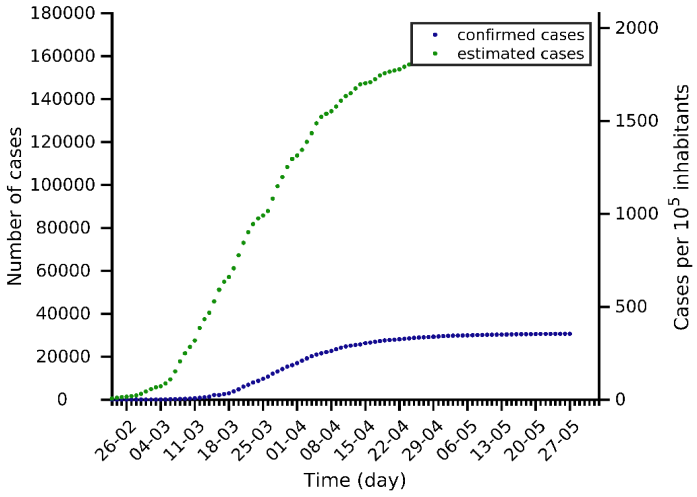


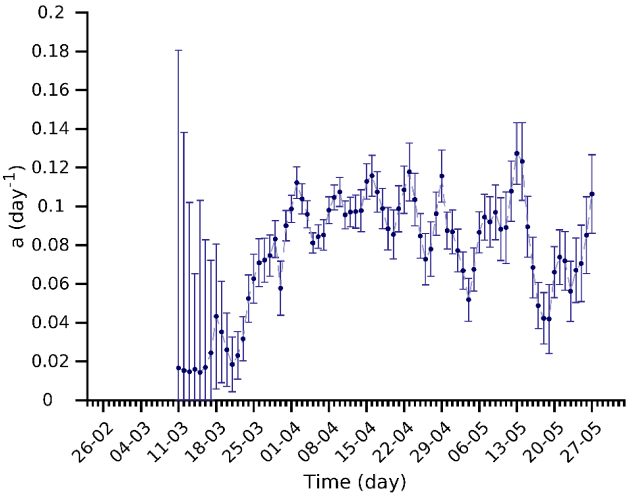


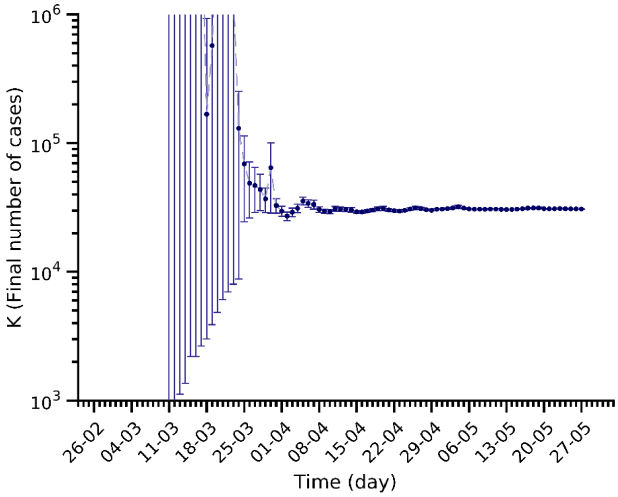


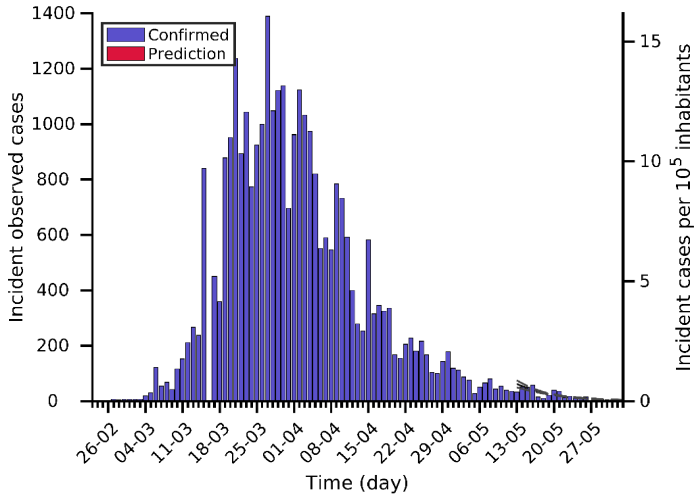
Switzerland 27-05-2020. Population: 8.7M. Current cumulated incidence: 354/10^5

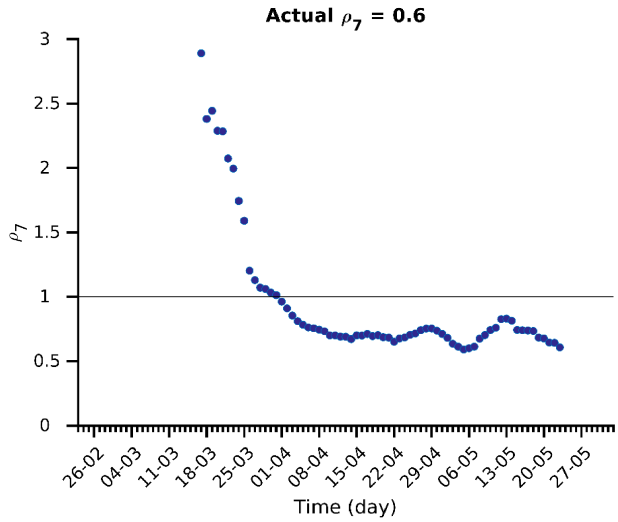


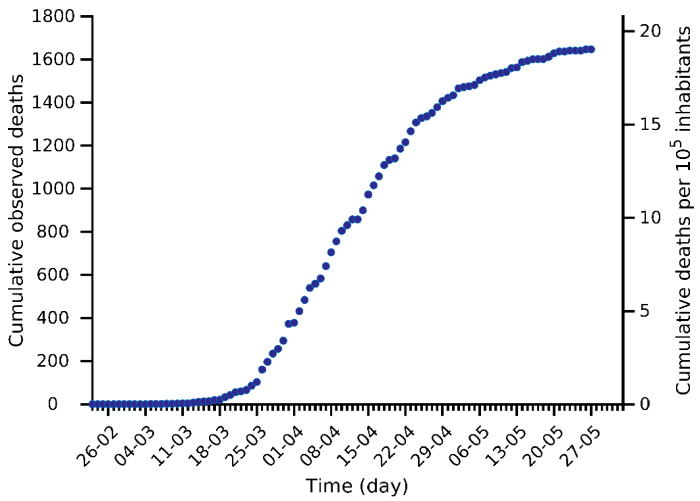


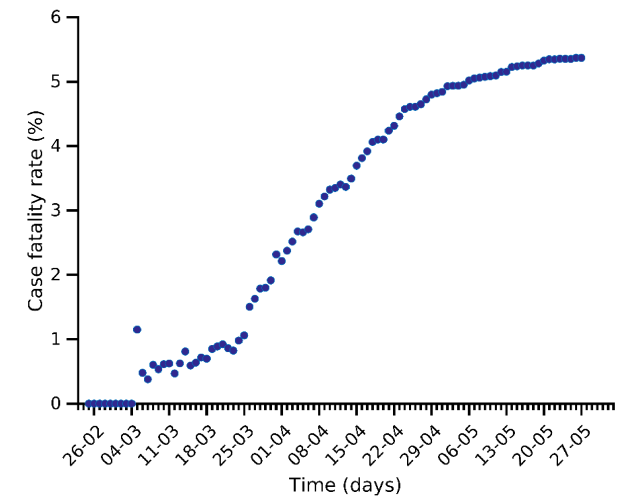




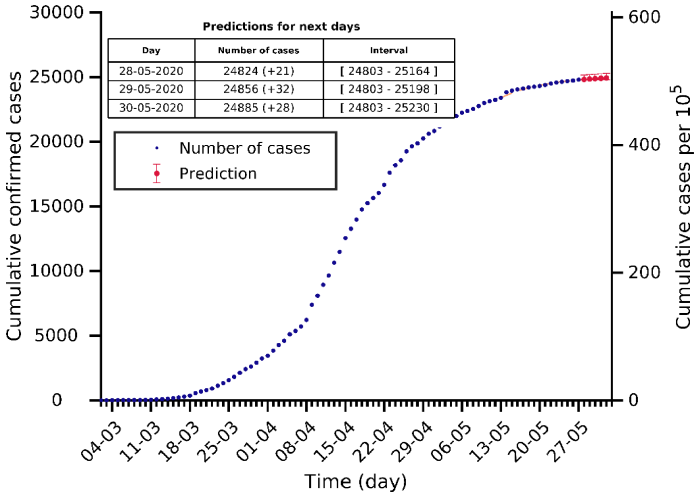


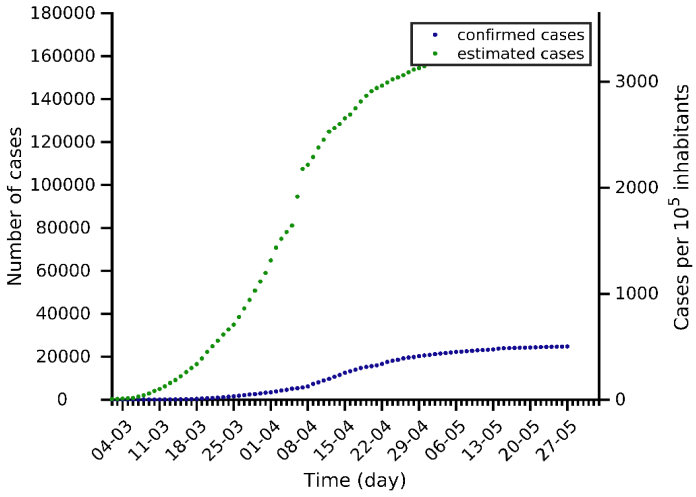


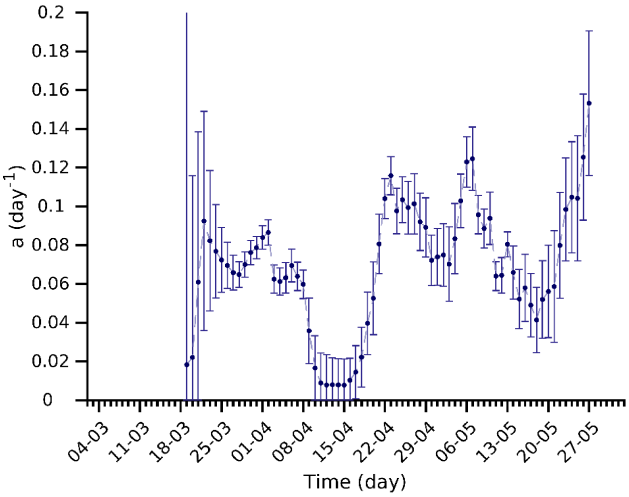


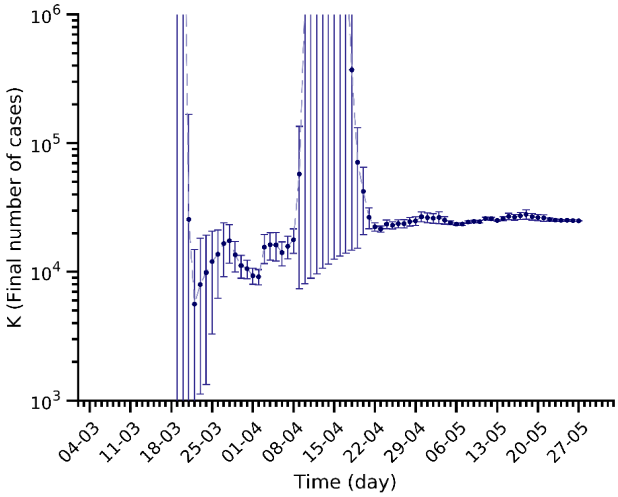


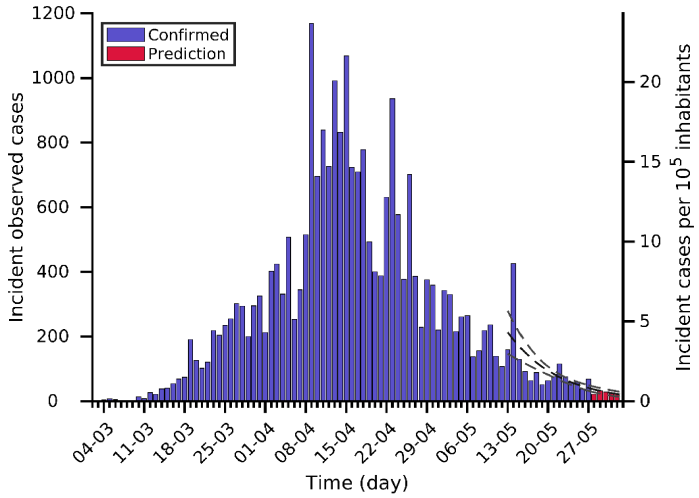
Ireland 27-05-2020. Population: 4.9M. Current cumulated incidence: 502/10^5

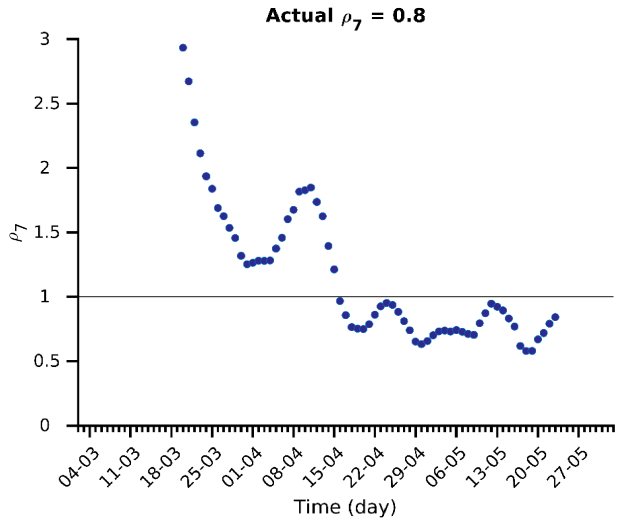


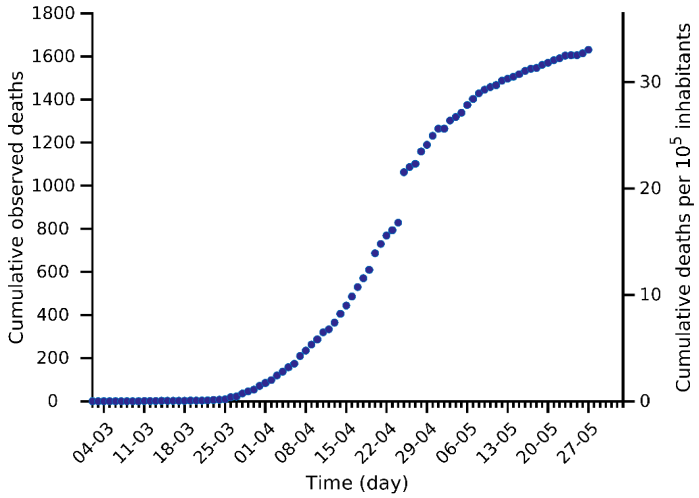


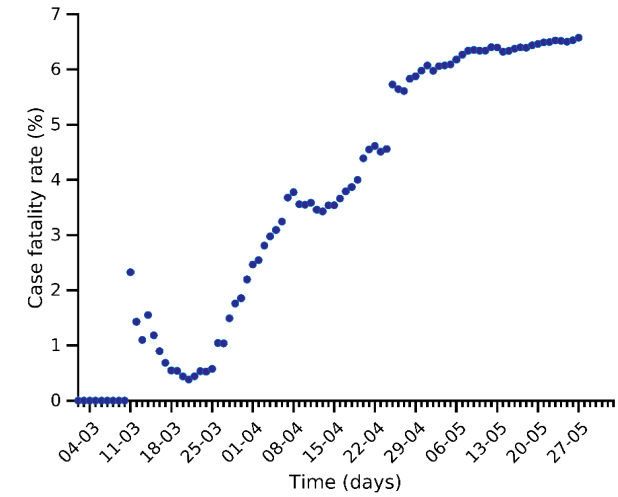




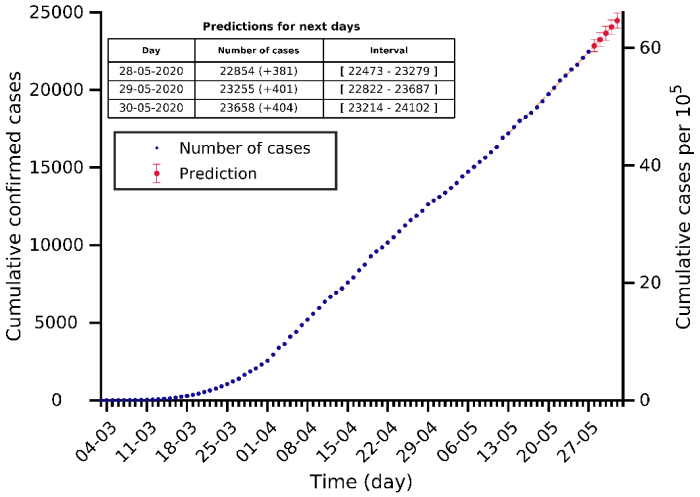


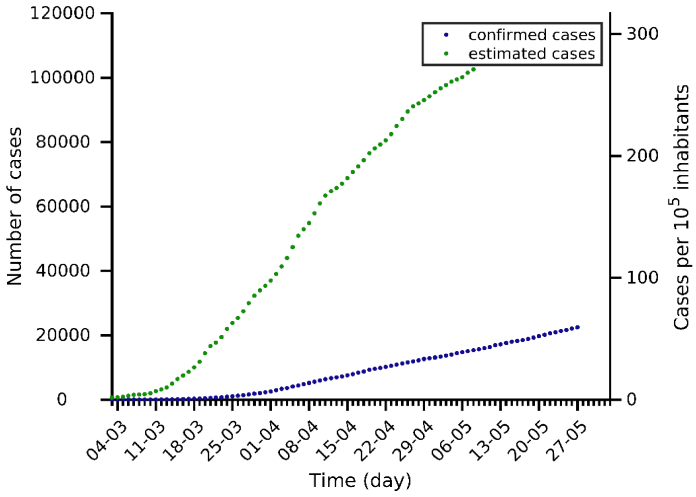


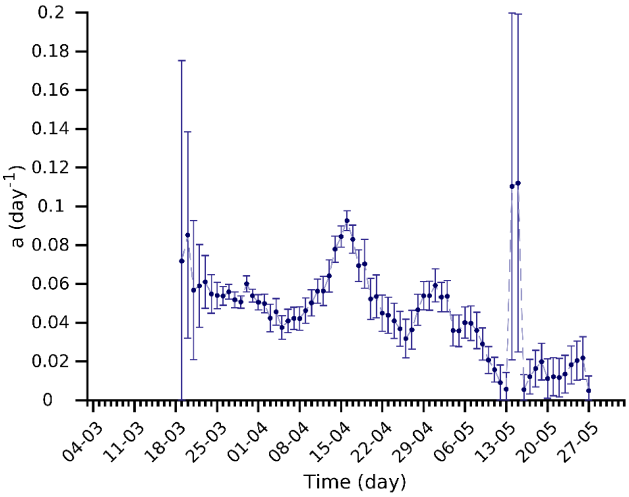


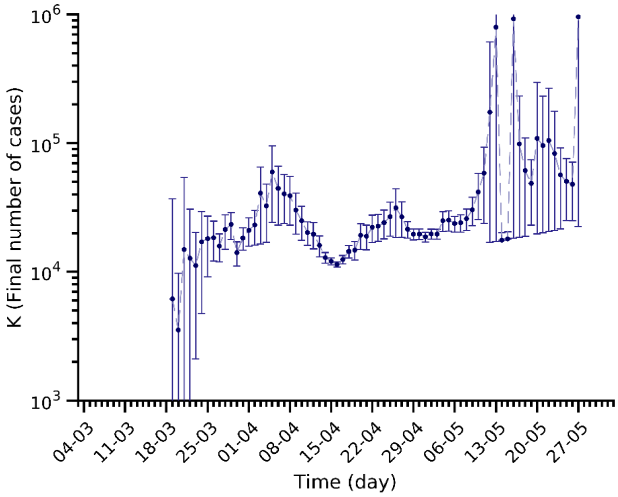


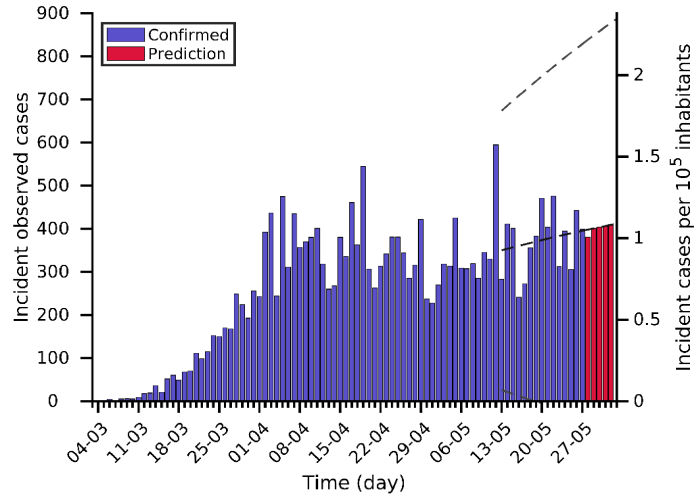
Poland 27-05-2020. Population: 37.8M. Current cumulated incidence: 59/10^5

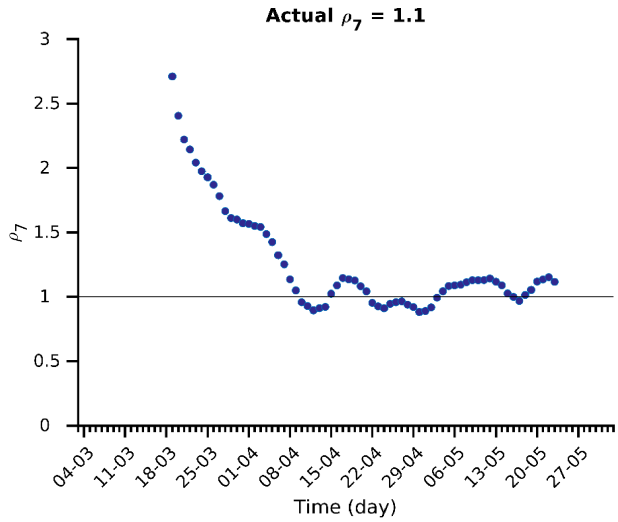


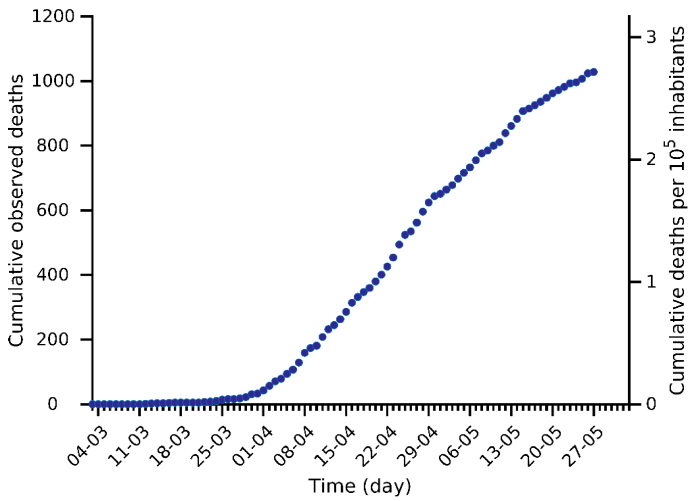


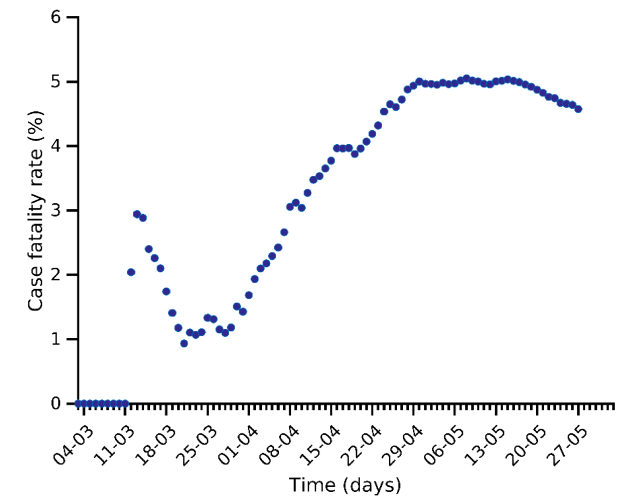




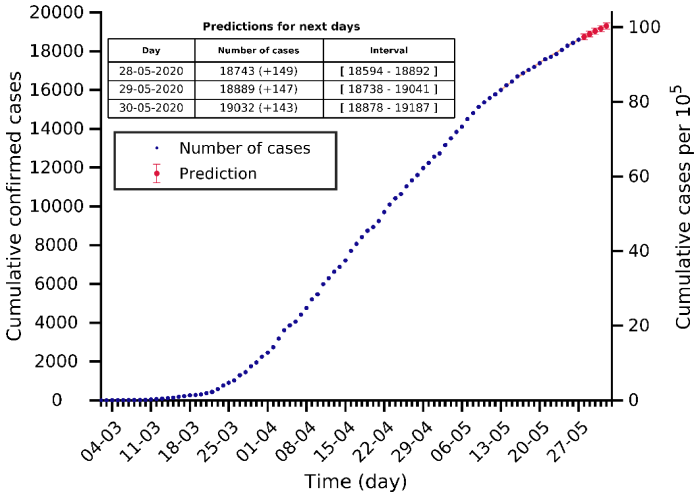


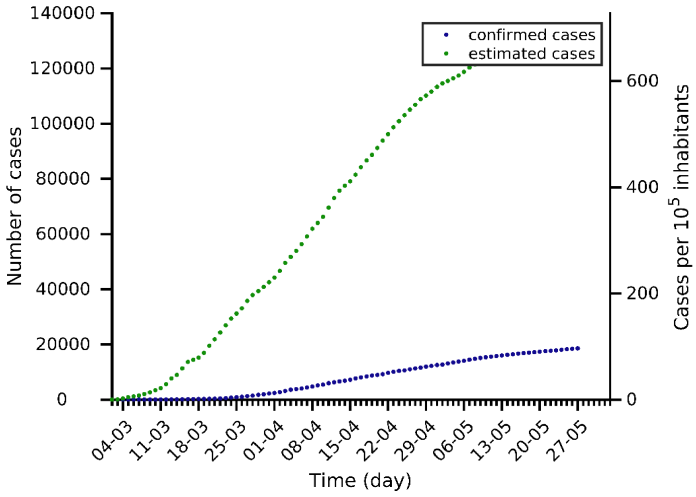


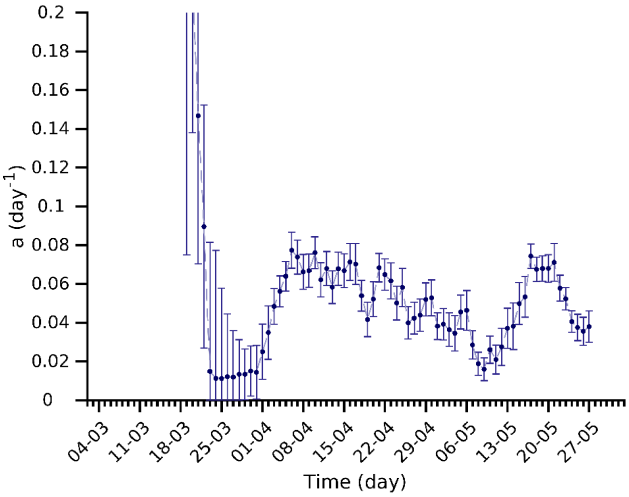


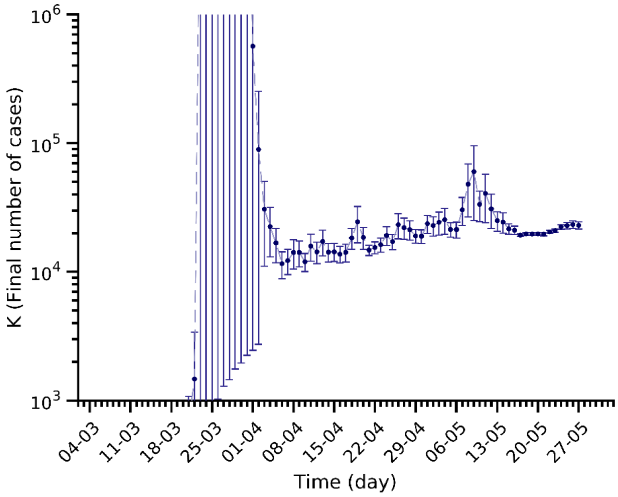


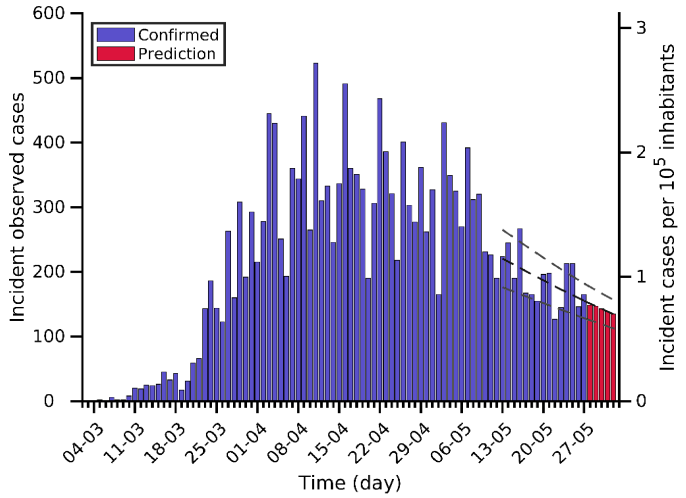
Romania 27-05-2020. Population: 19.2M. Current cumulated incidence: $97/10^5$

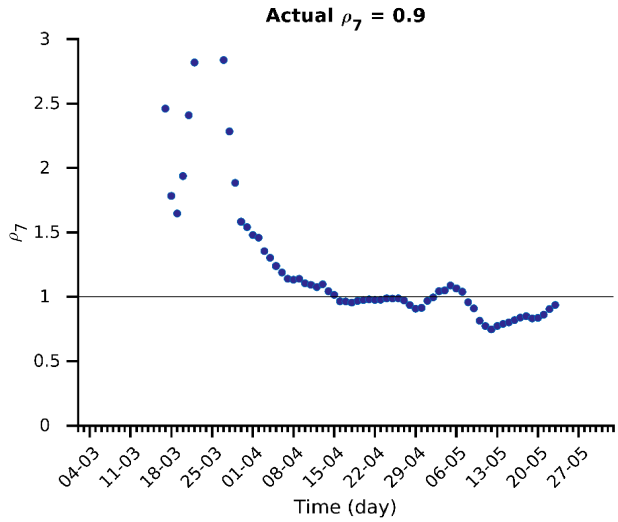


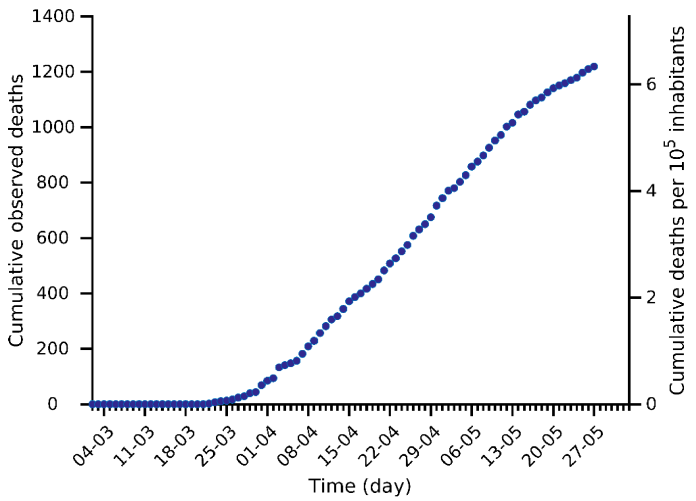


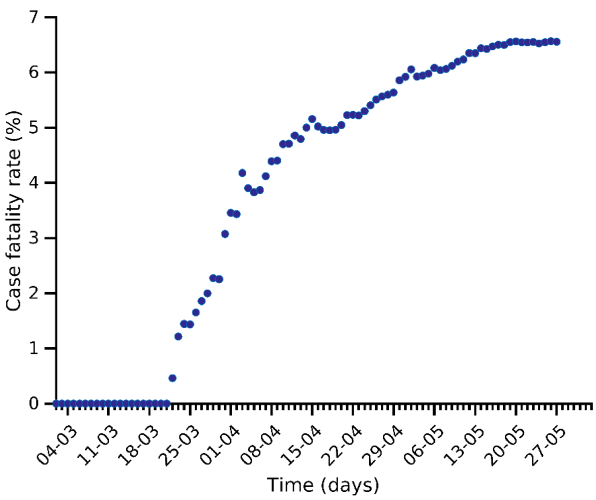




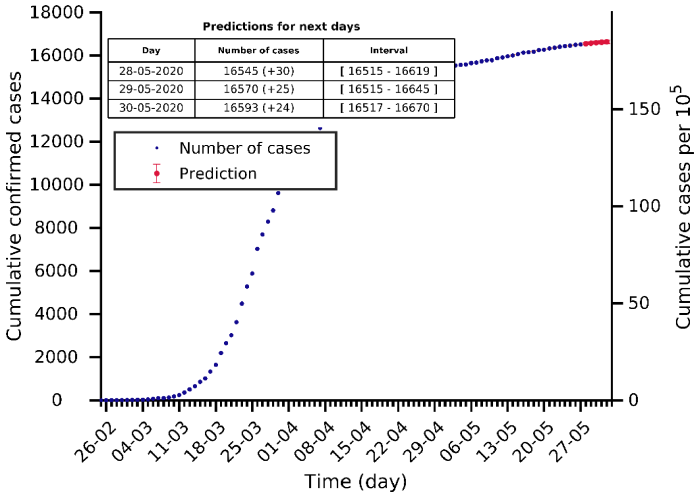


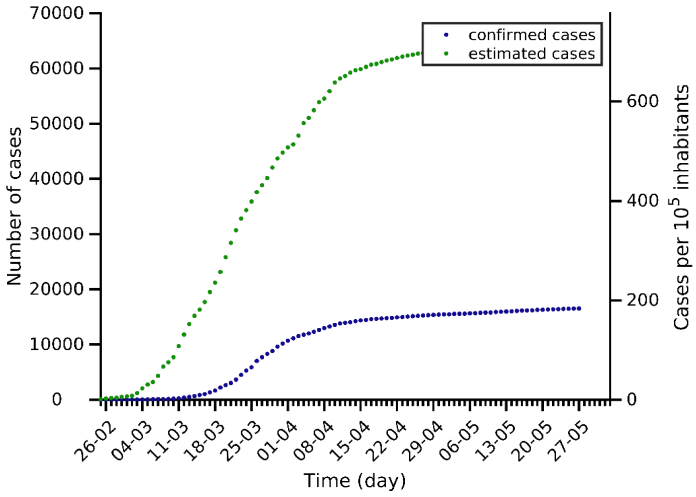


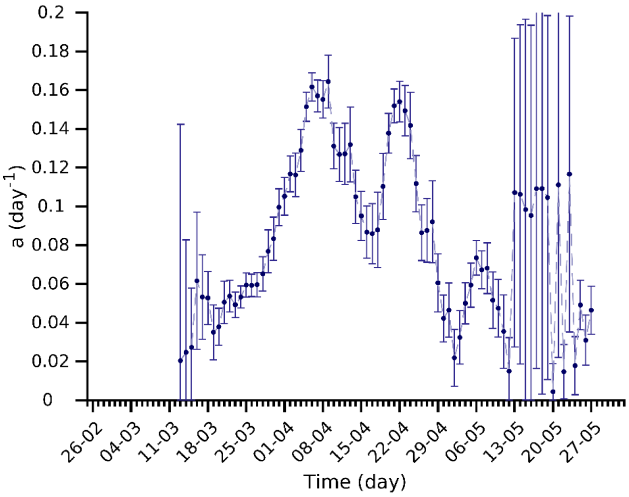


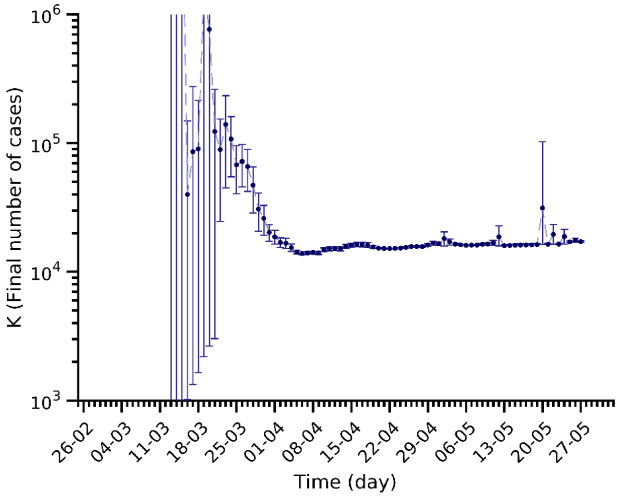


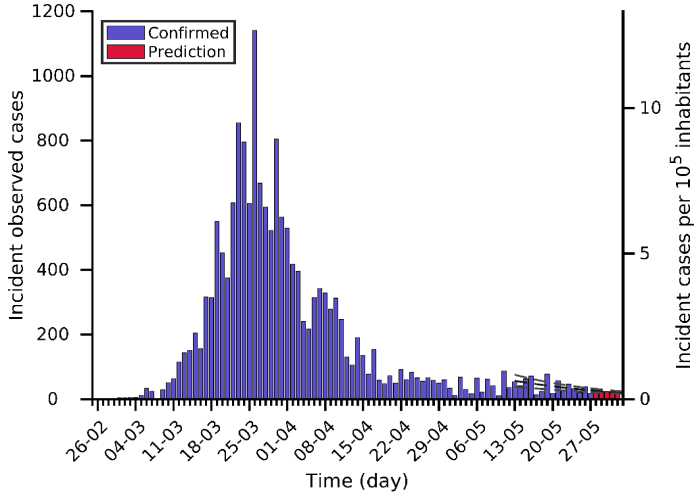
Austria 27-05-2020. Population: 9.0M. Current cumulated incidence: 183/10^5

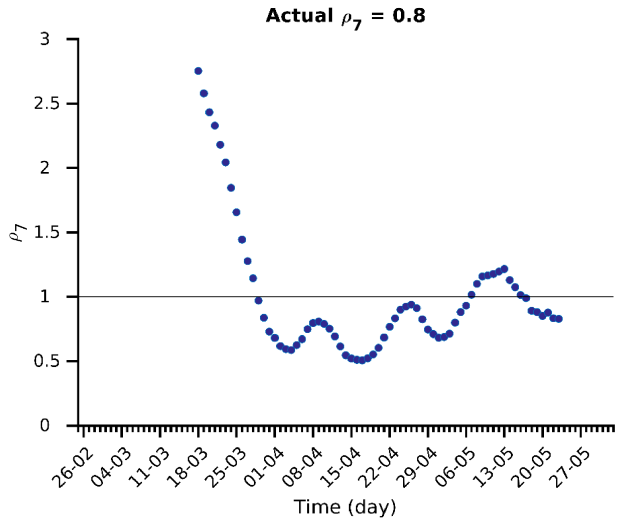


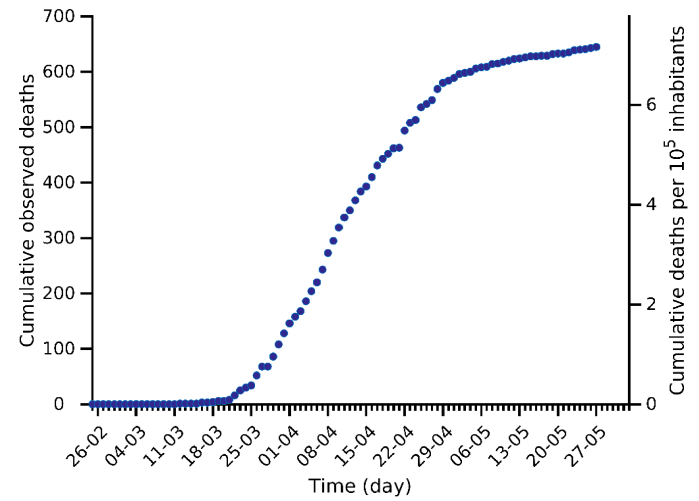


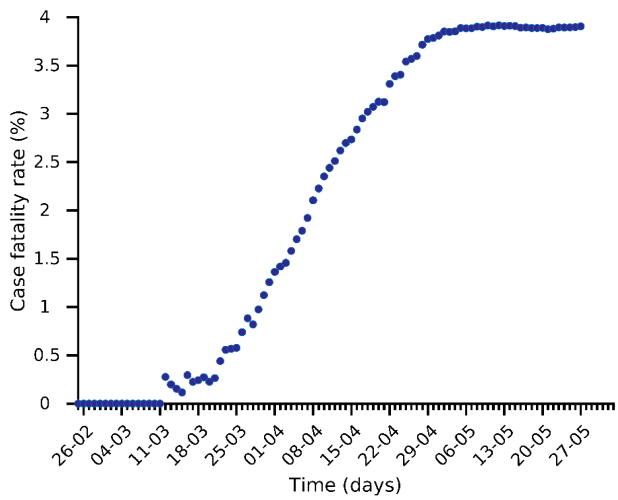




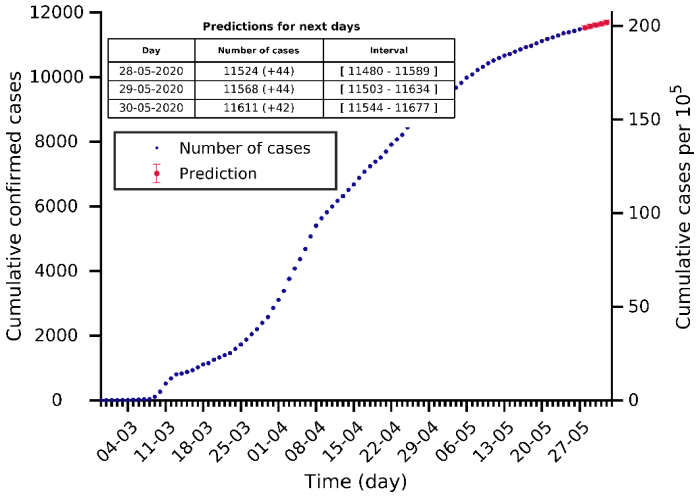


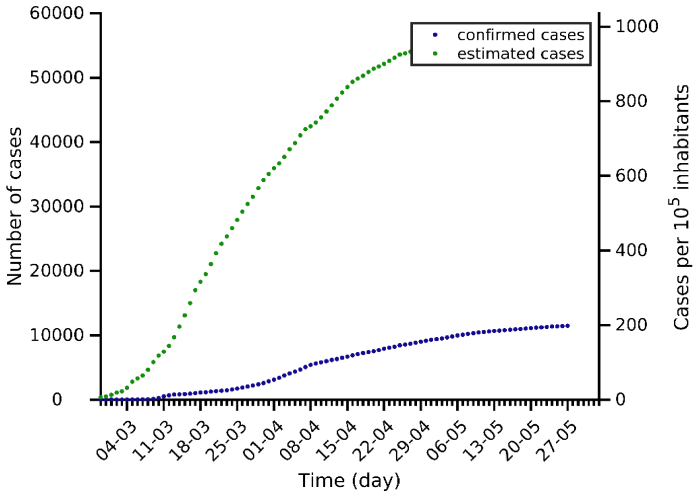


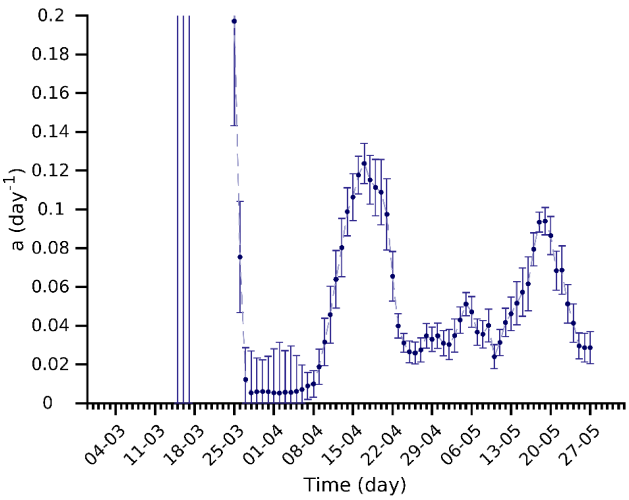


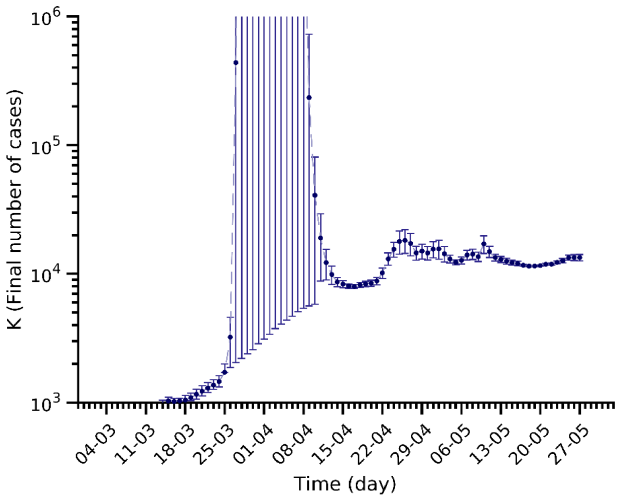


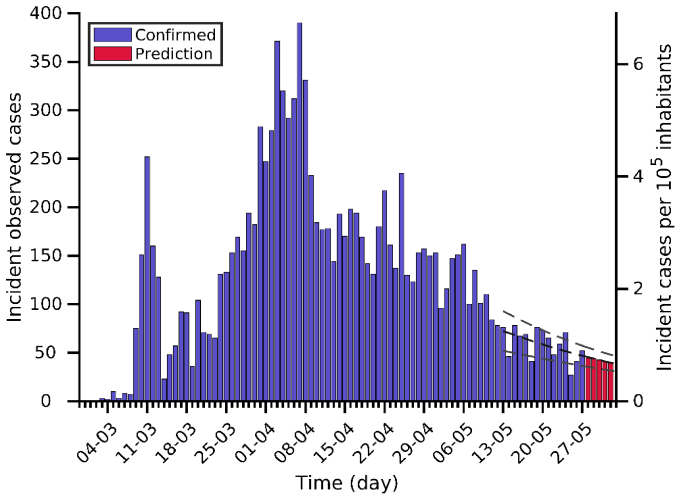
Denmark 27-05-2020. Population: 5.8M. Current cumulated incidence: 198/10^5

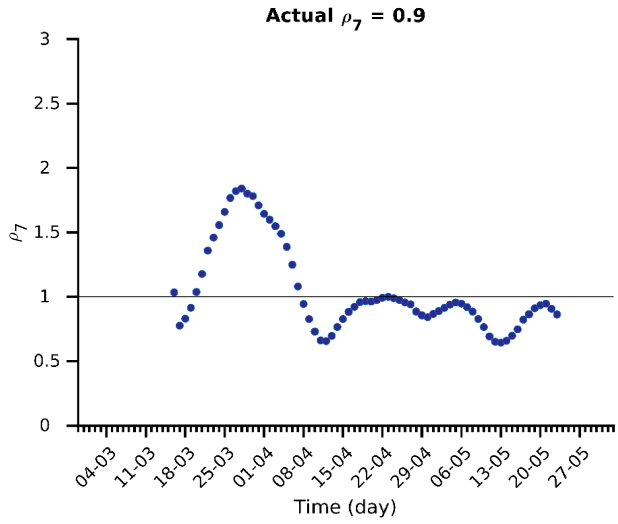


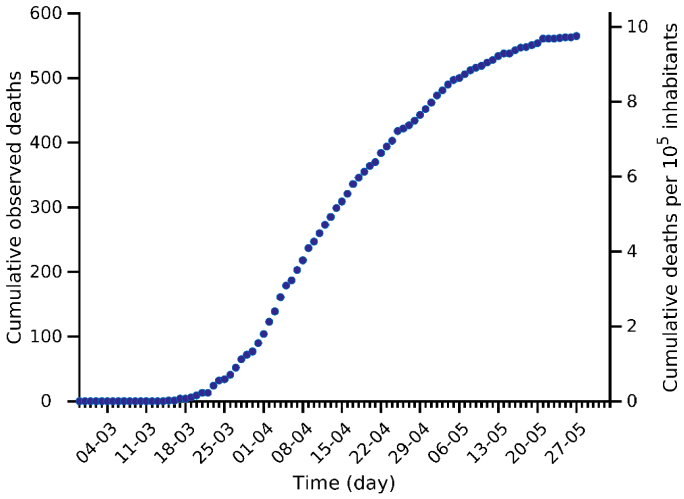


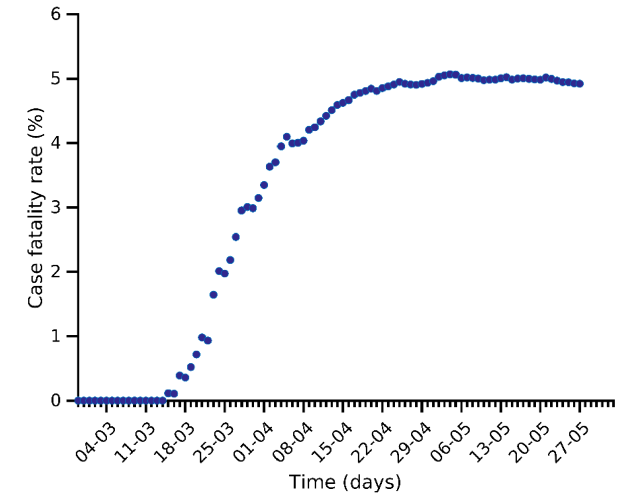




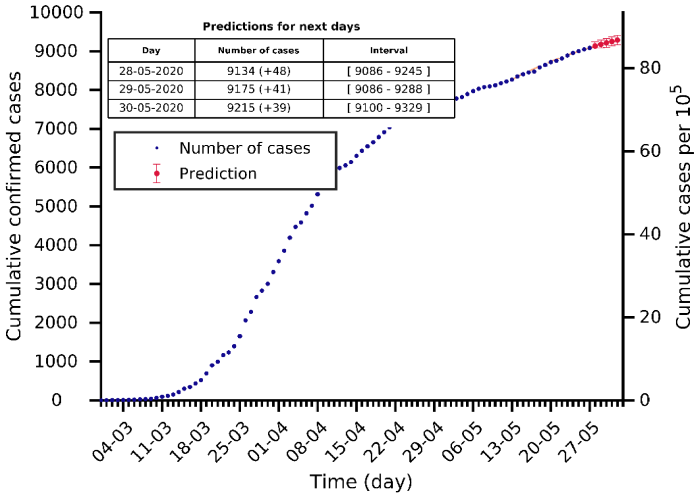


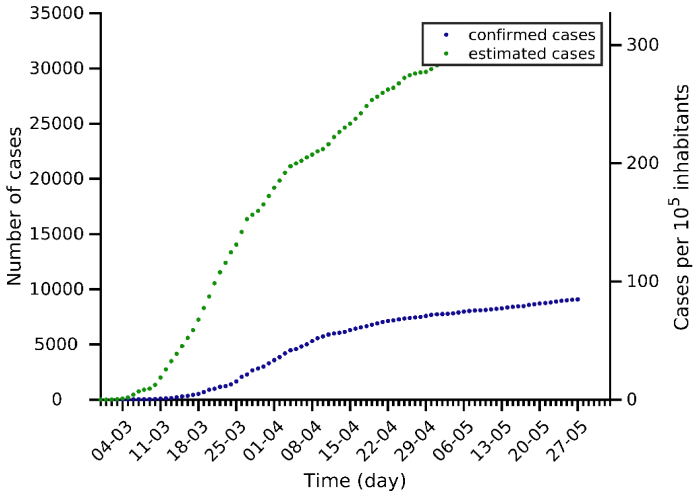


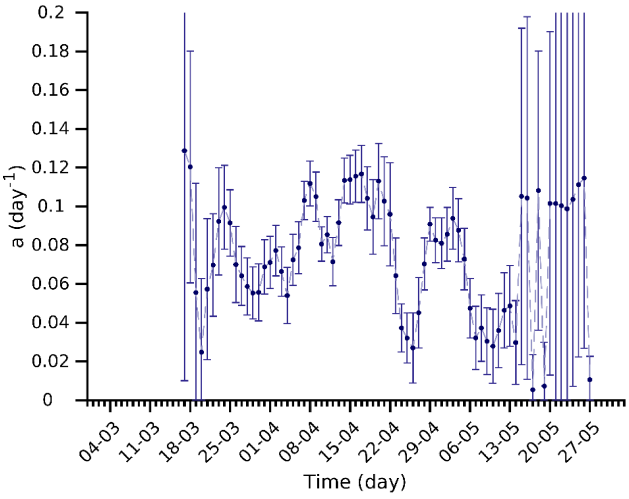


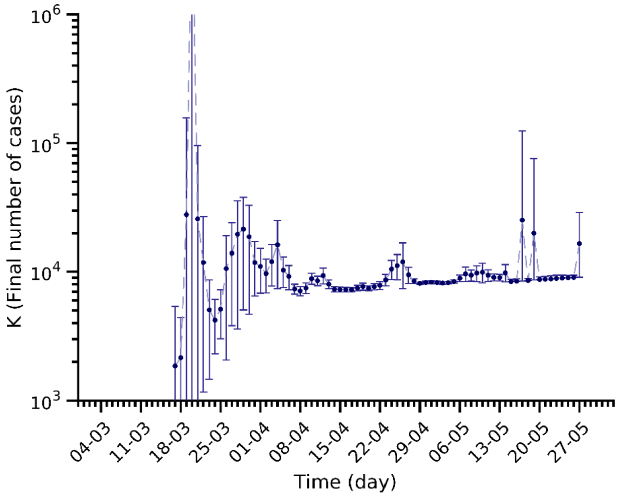


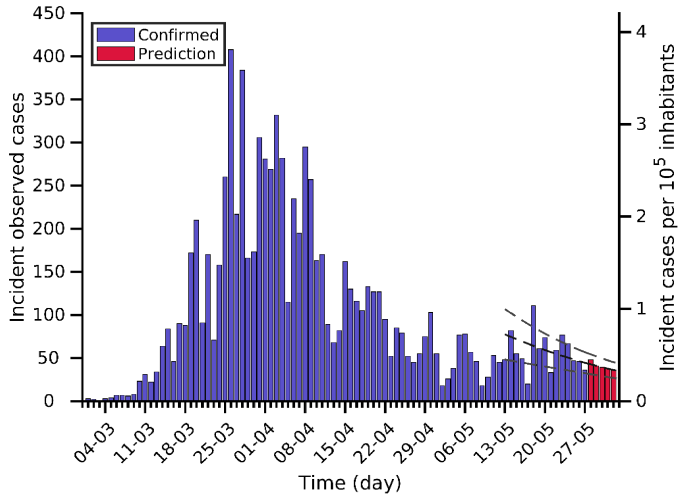
Czech Rep 27-05-2020. Population: 10.7M. Current cumulated incidence: 85/10^5

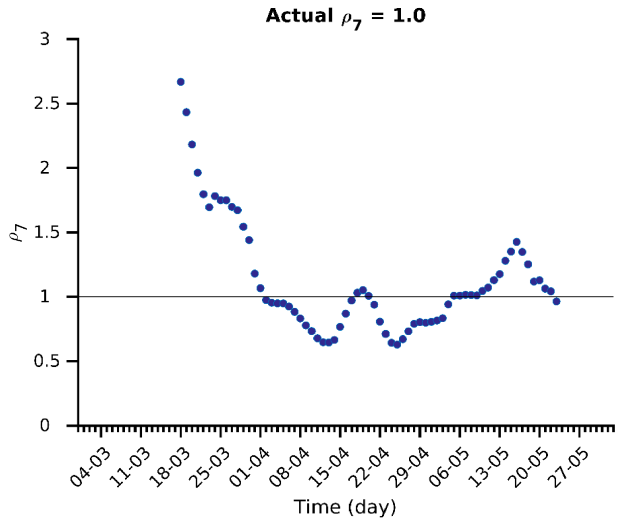


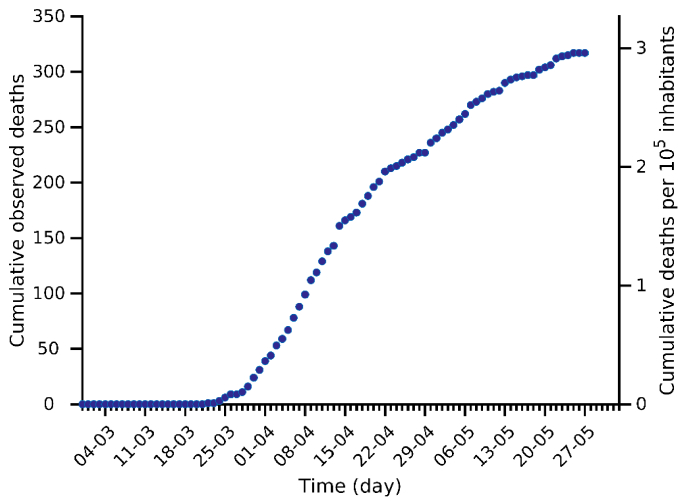


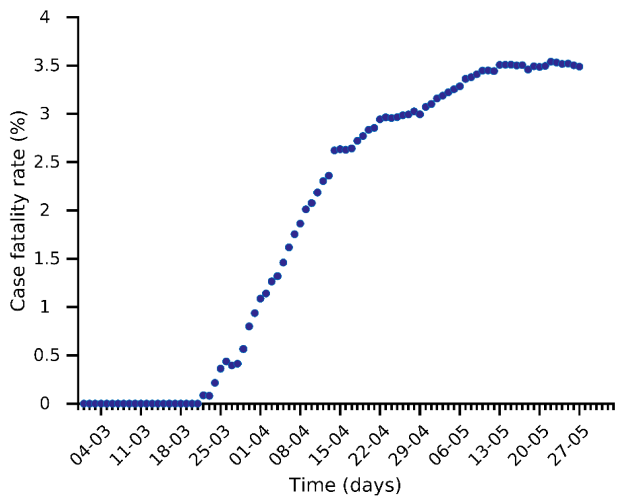




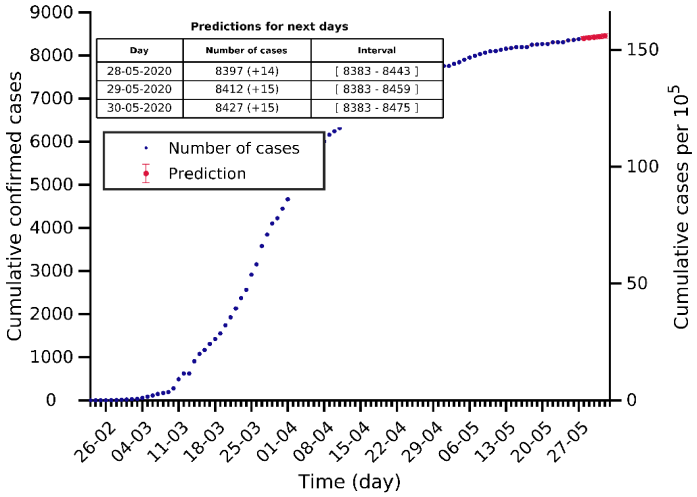


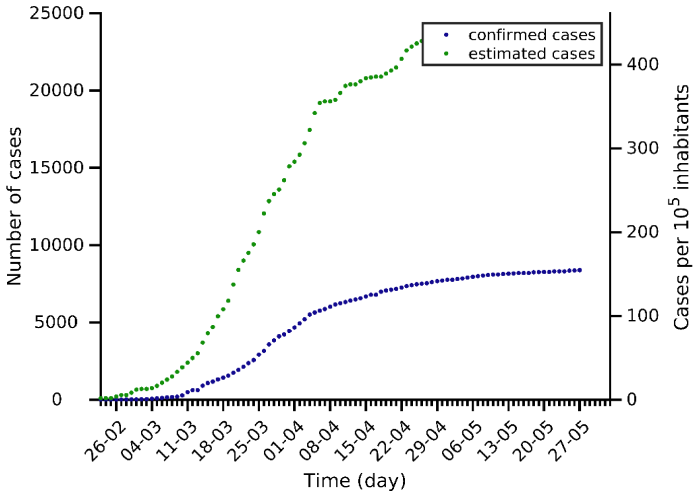


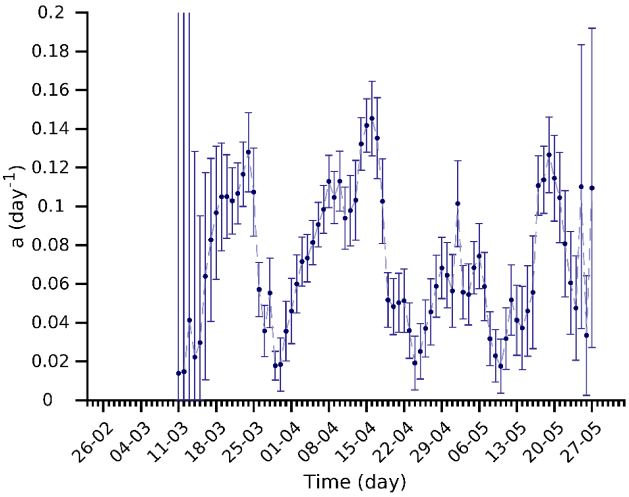


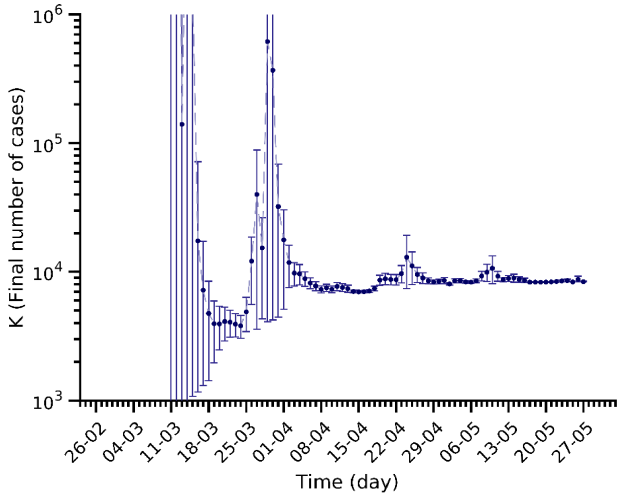


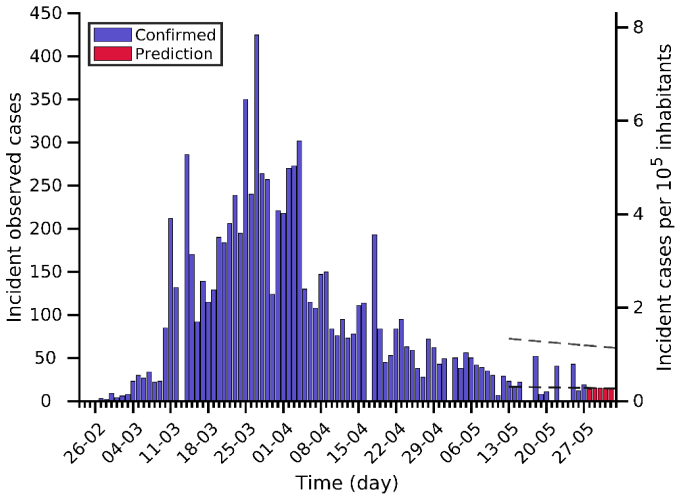
Norway 27-05-2020. Population: 5.4M. Current cumulated incidence: 155/10⁵

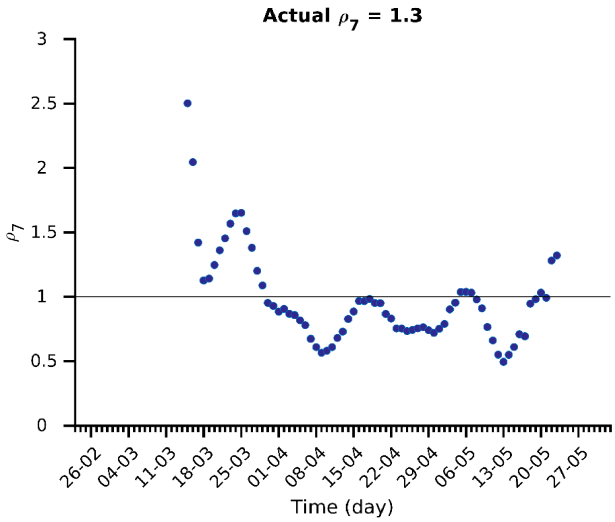


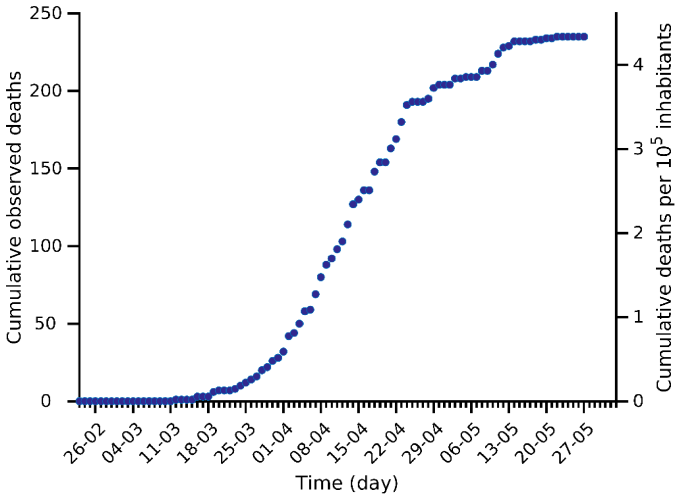


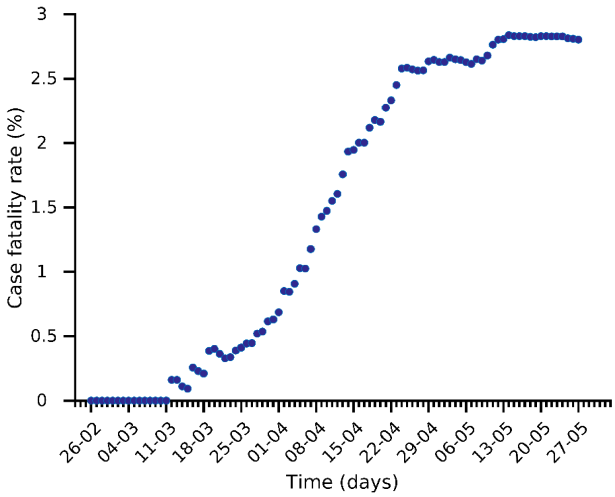




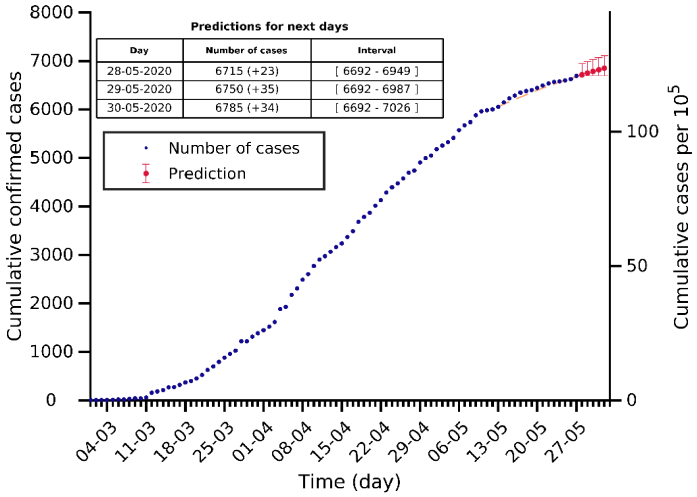


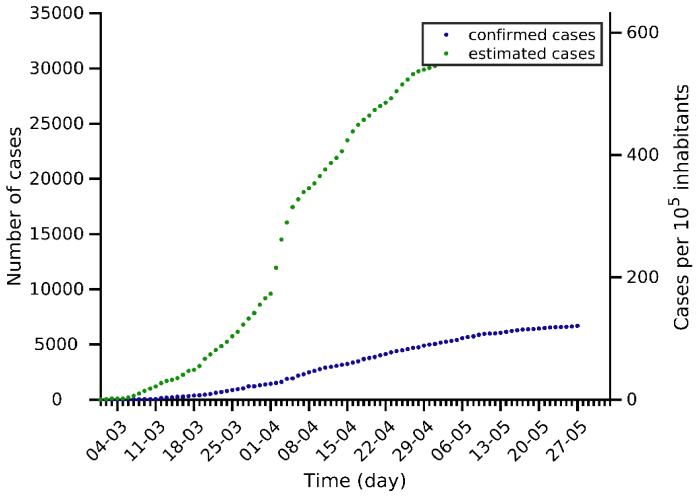


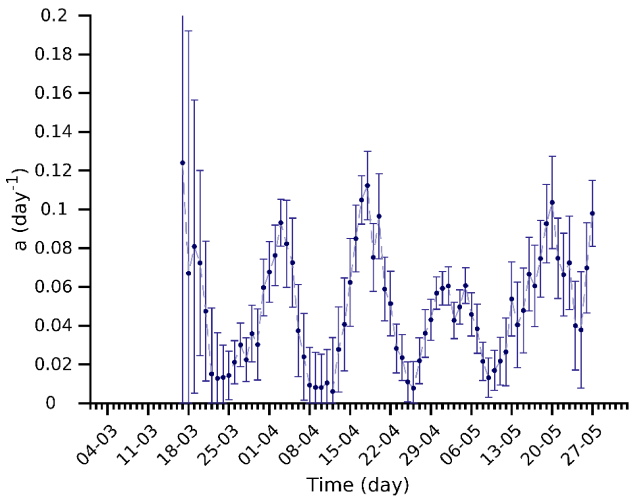


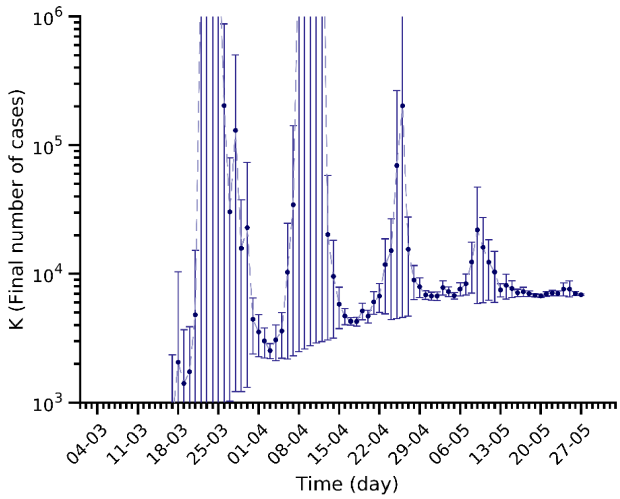


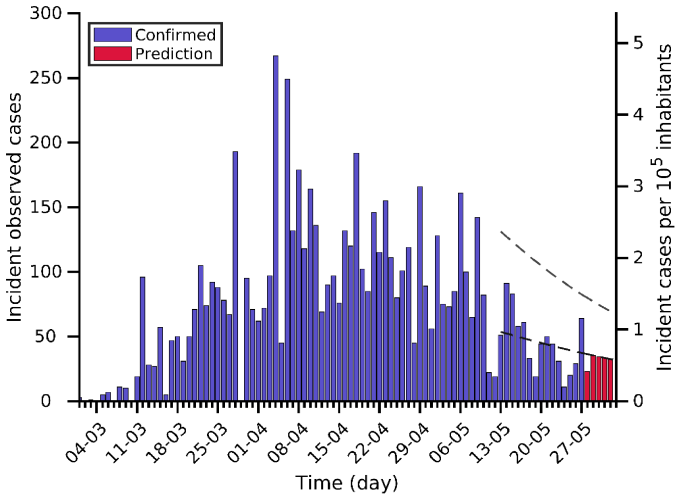
Finland 27-05-2020. Population: 5.5M. Current cumulated incidence: 121/10⁵

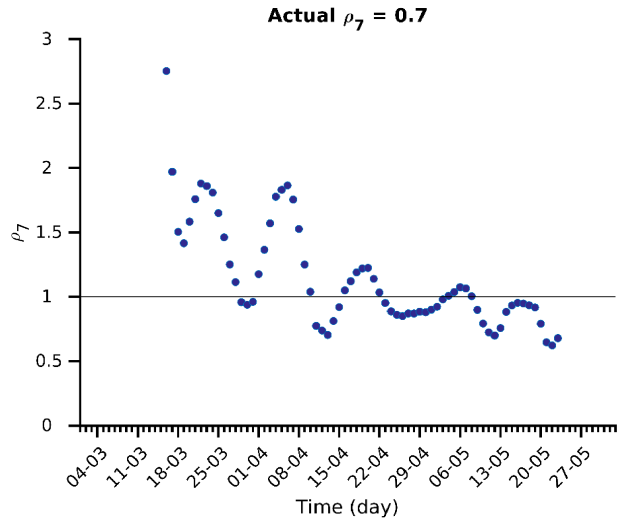


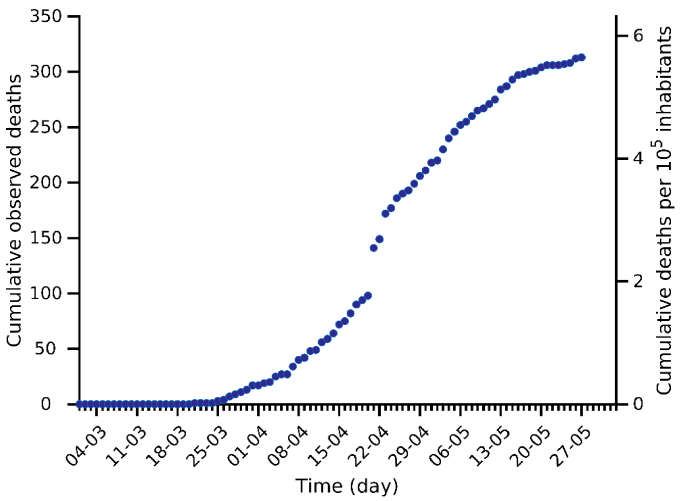


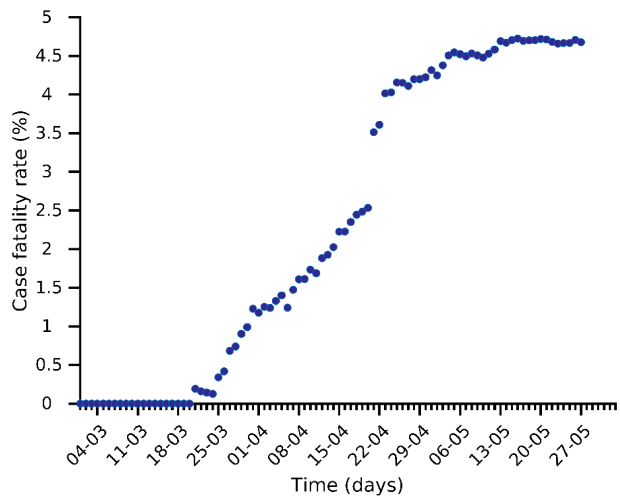




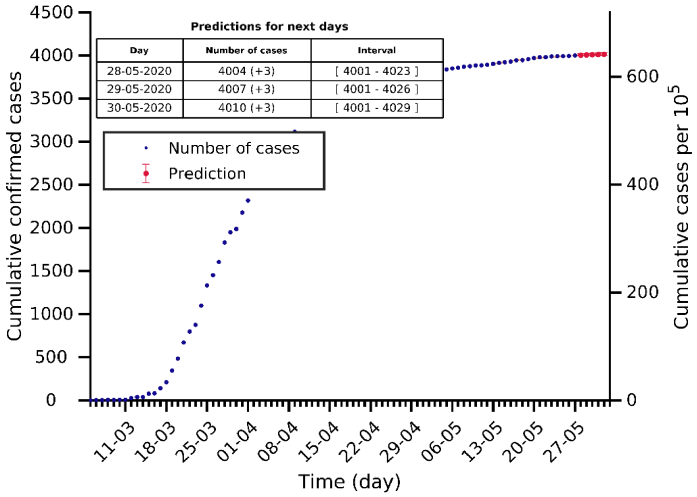


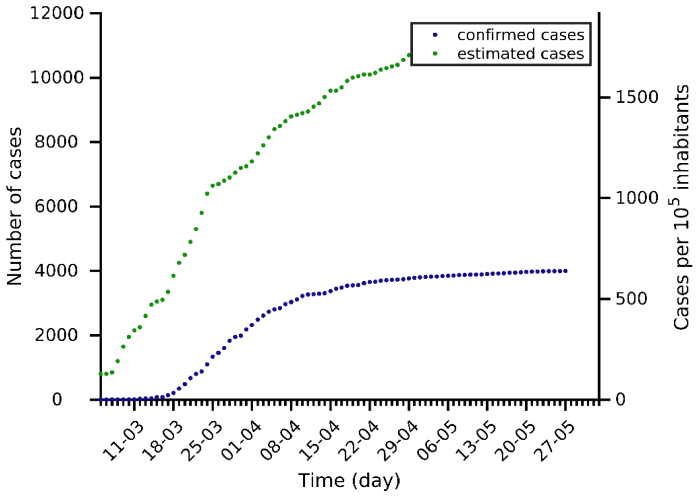


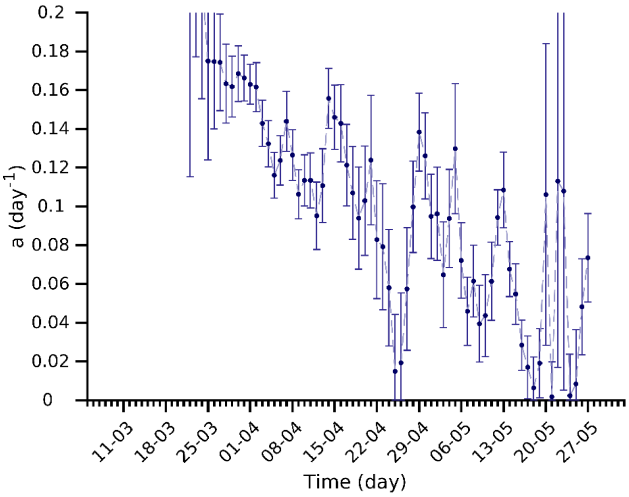


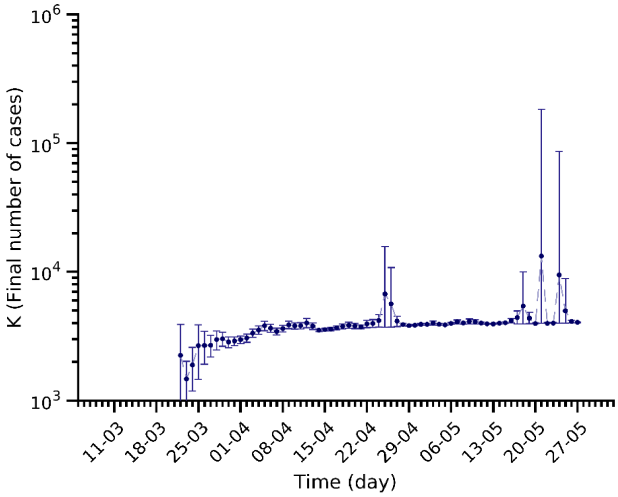


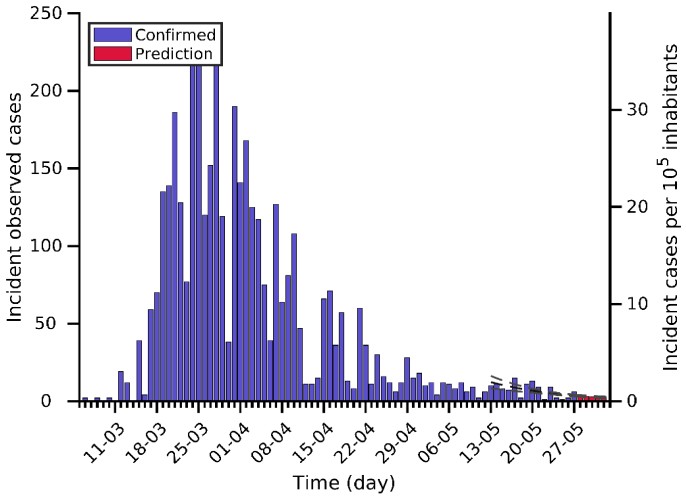
Luxembourg 27-05-2020. Population: 0.6M. Current cumulated incidence: 639/10^5

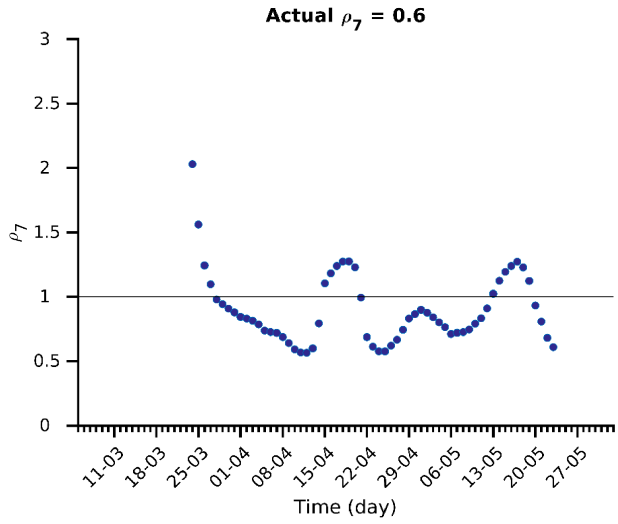


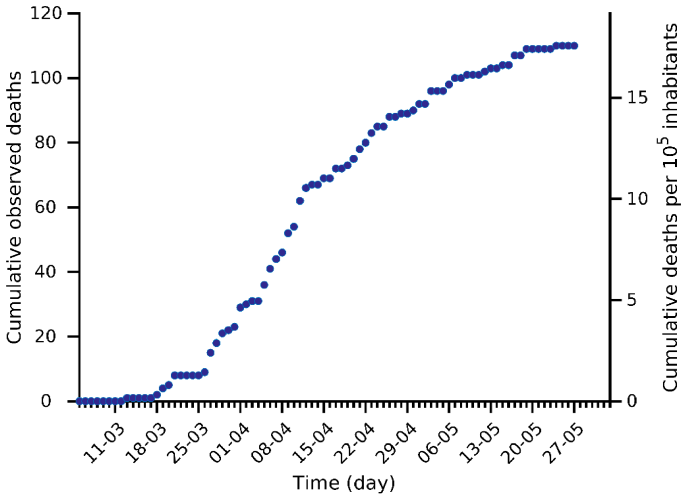


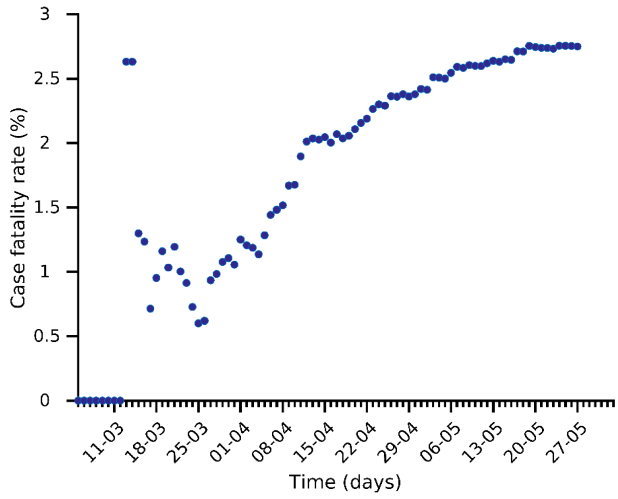




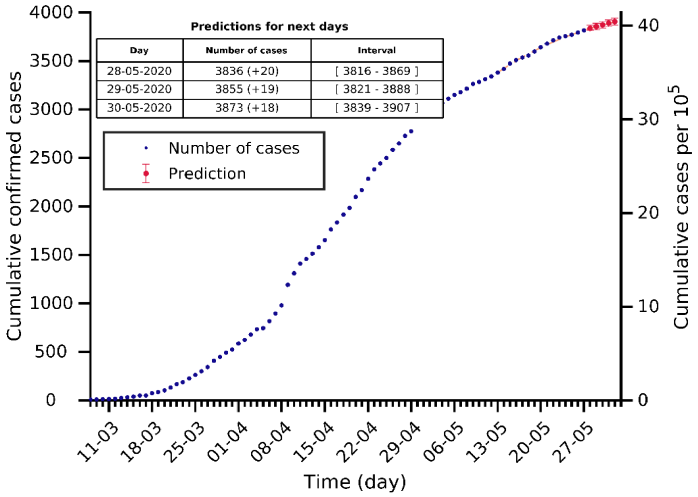


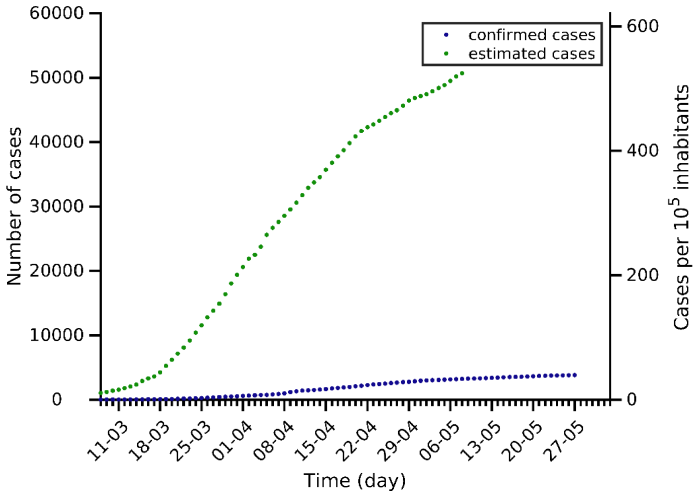


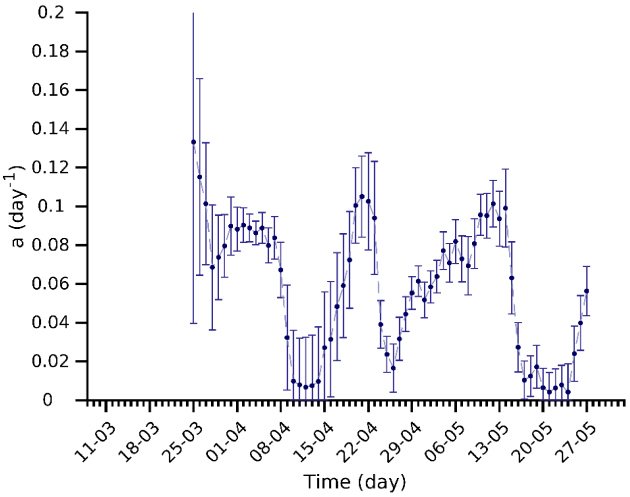


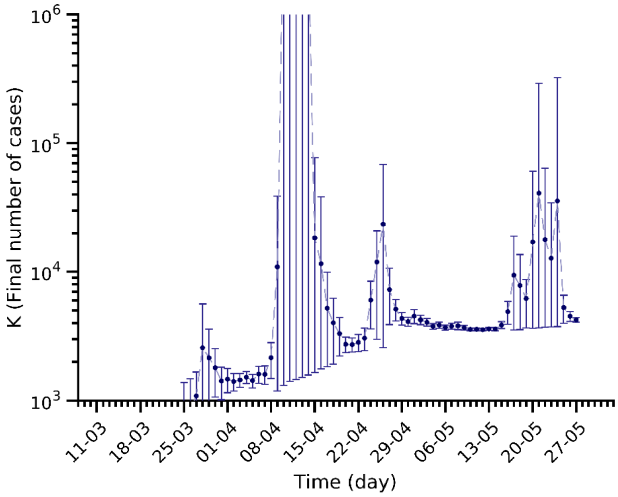


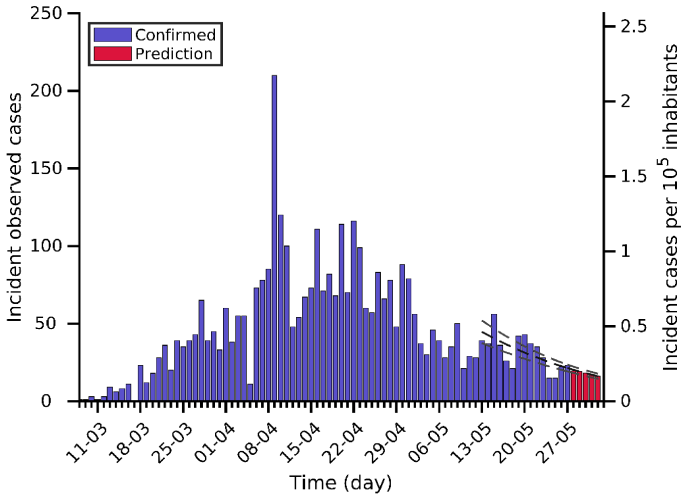
Hungary 27-05-2020. Population: 9.7M. Current cumulated incidence: $40/10^5$

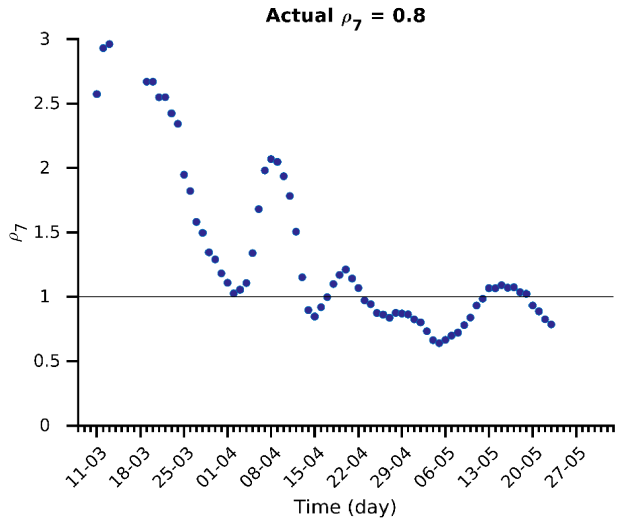


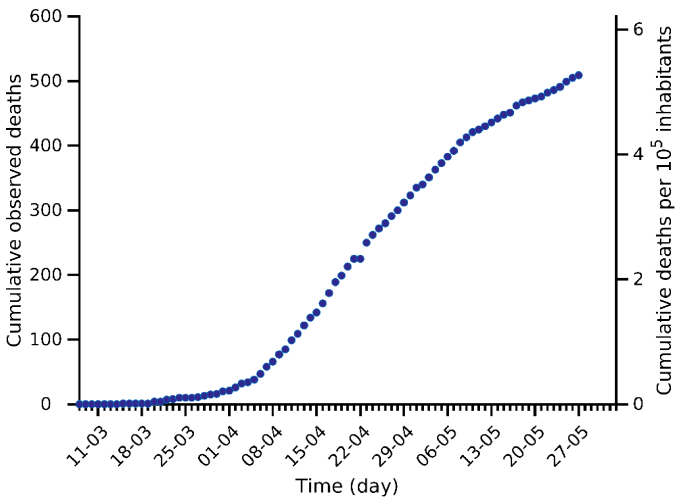


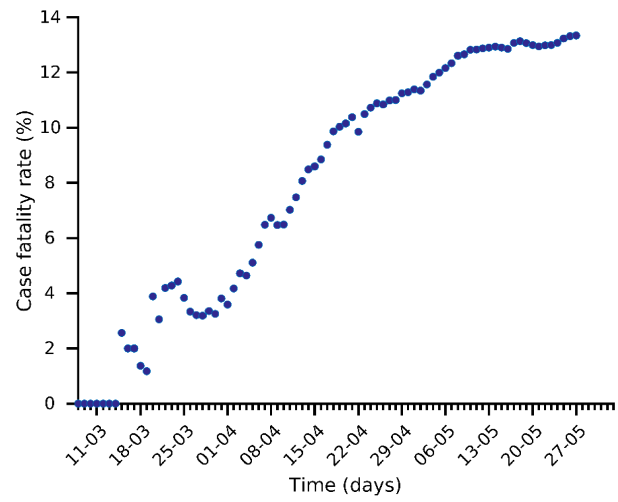




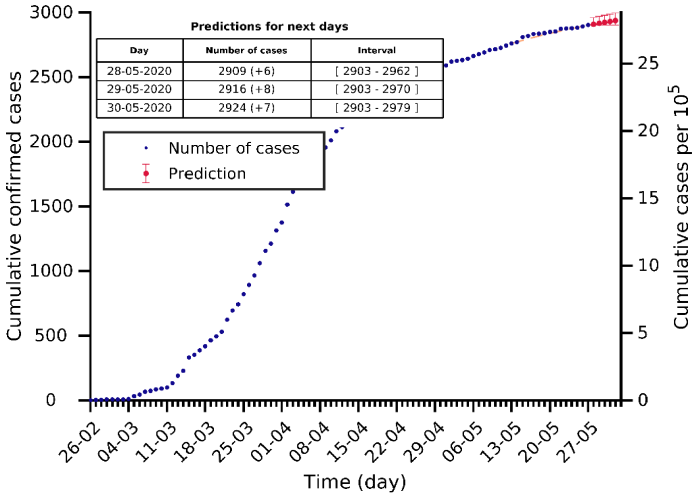


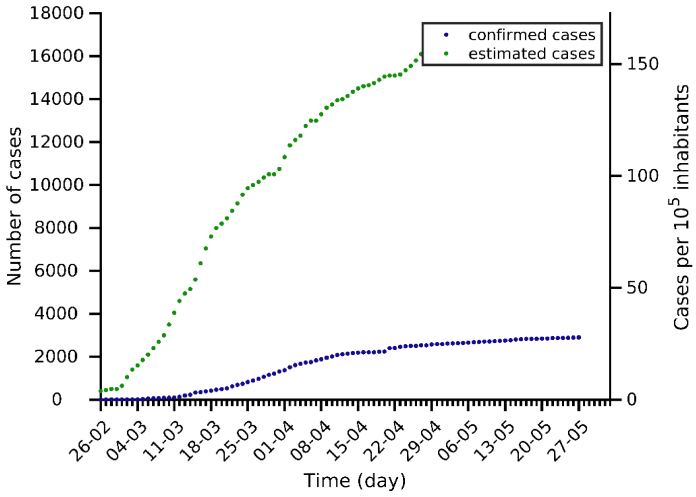


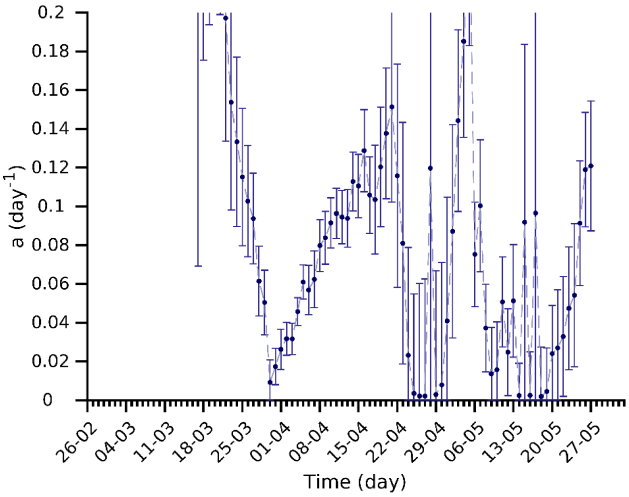


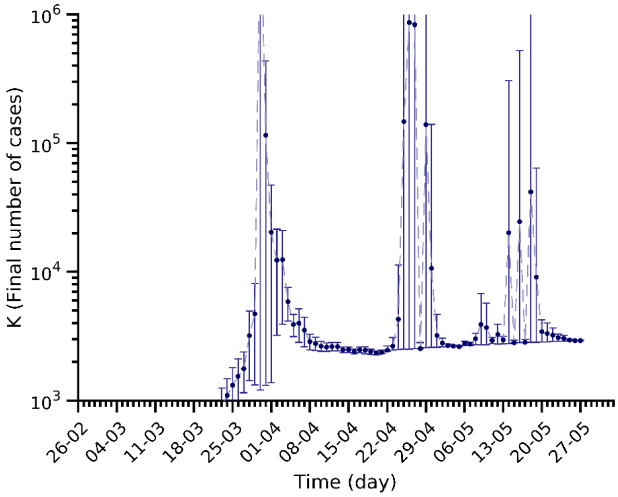


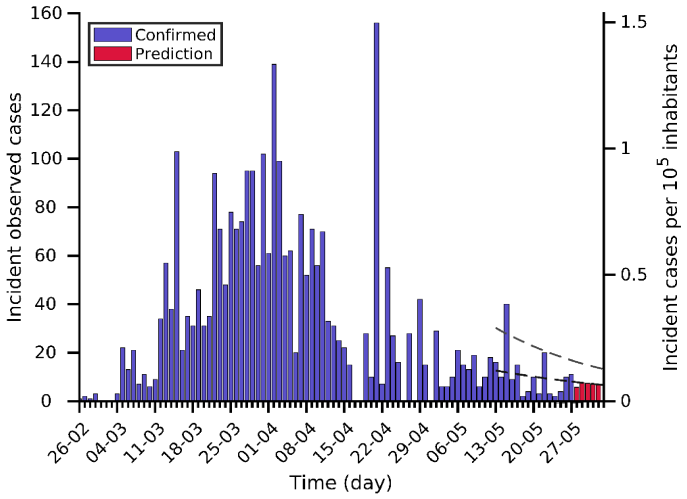
Greece 27-05-2020. Population: 10.4M. Current cumulated incidence: $28/10^5$

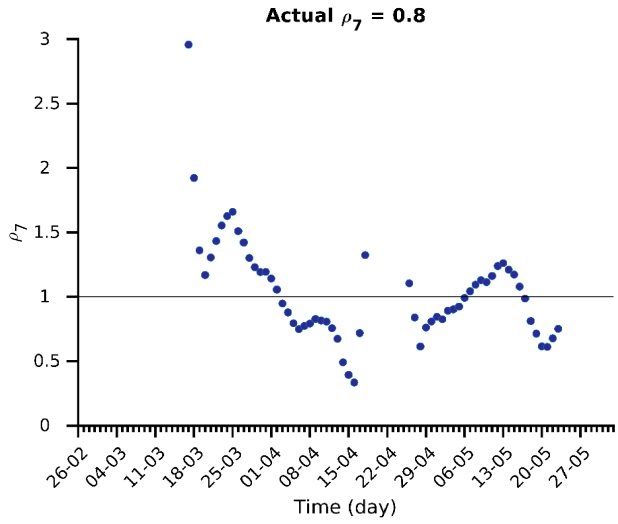


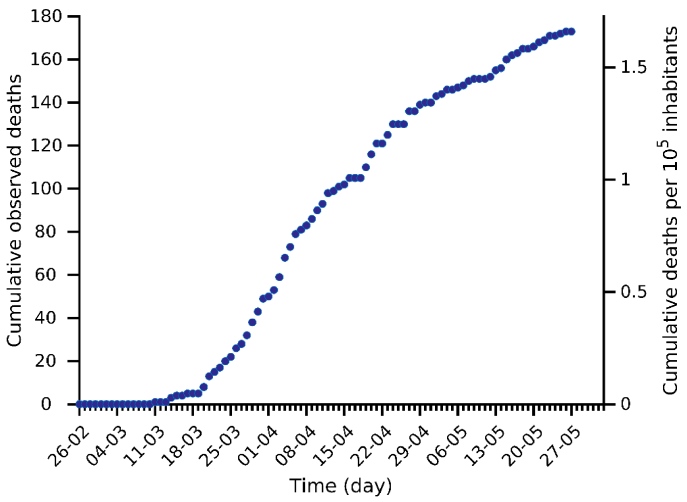


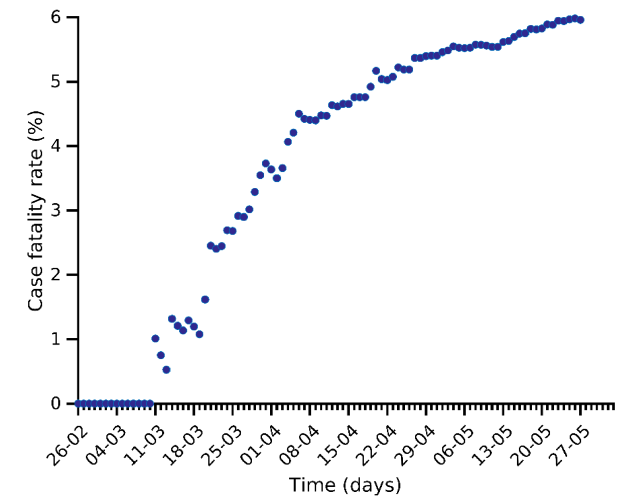




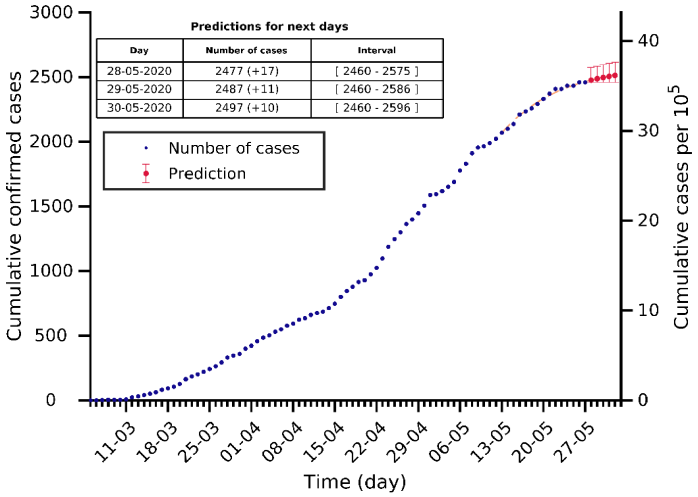


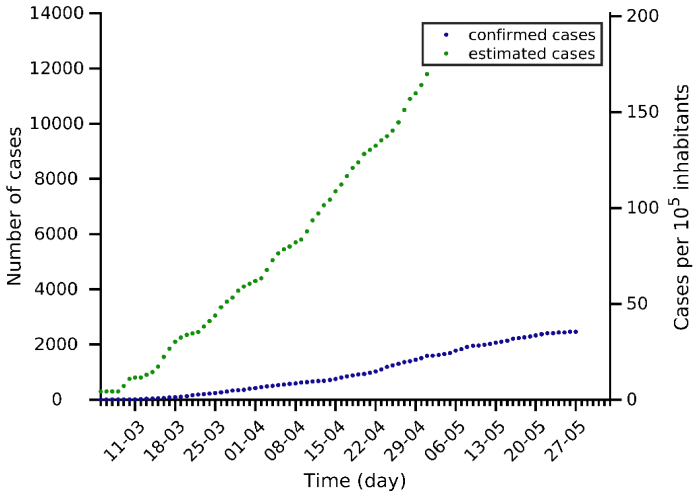


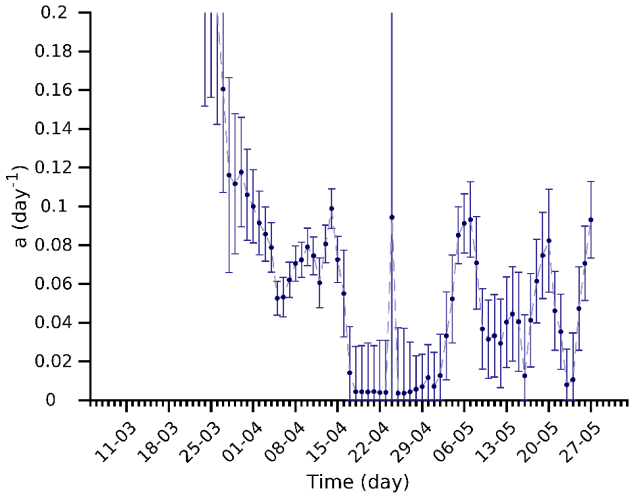


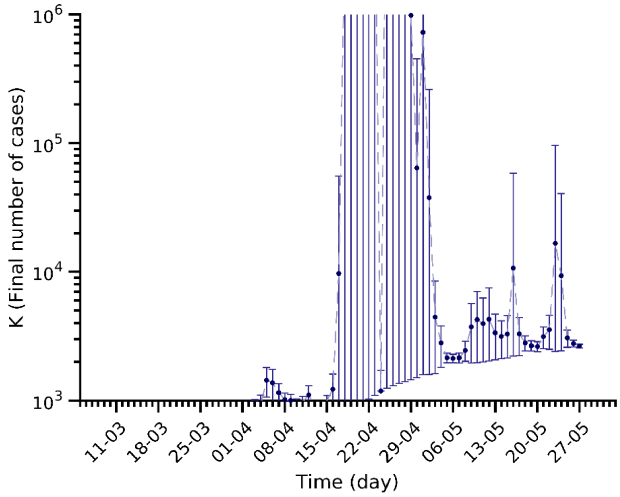


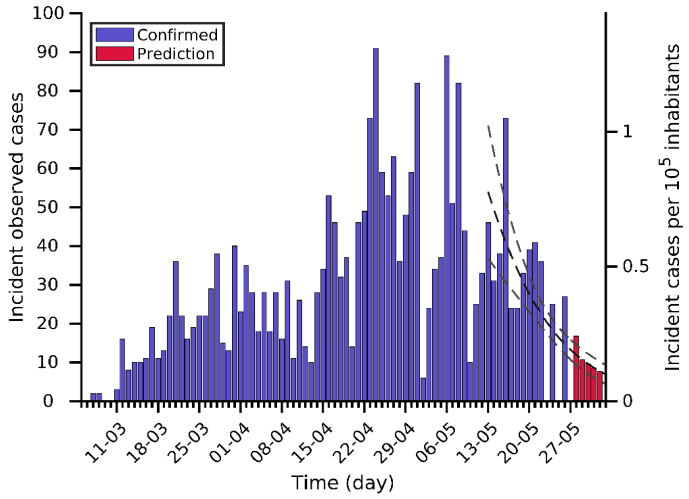
Bulgaria 27-05-2020. Population: 6.9M. Current cumulated incidence: $35/10^5$

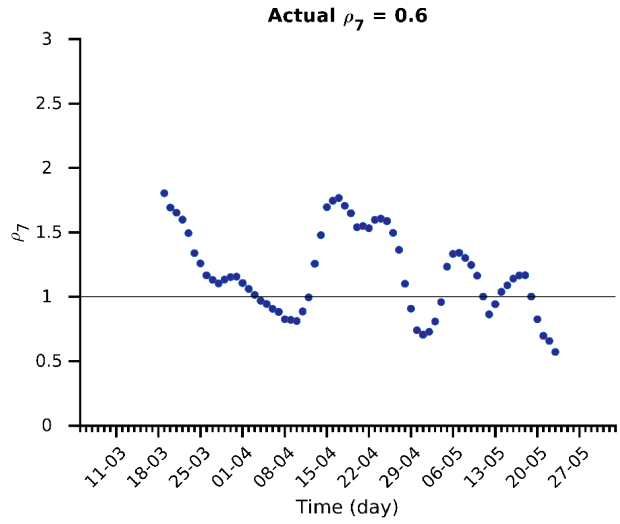


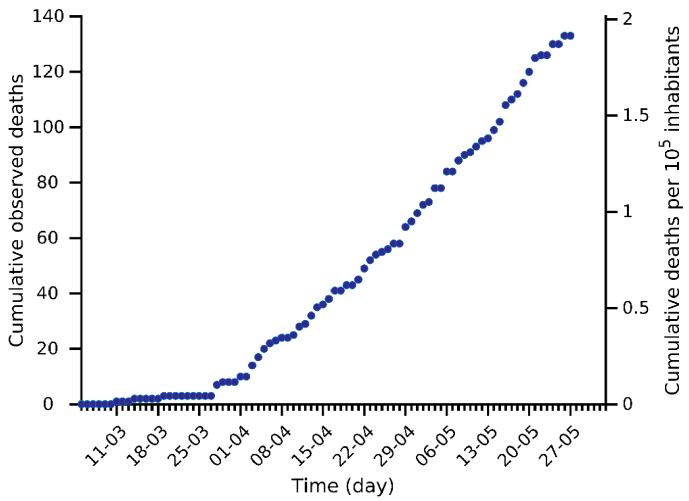


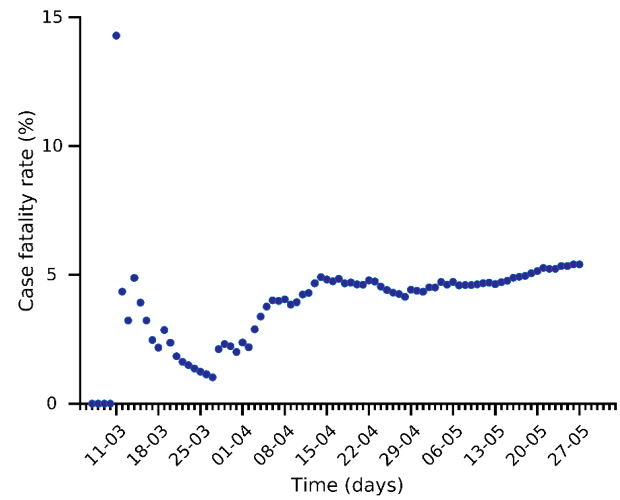




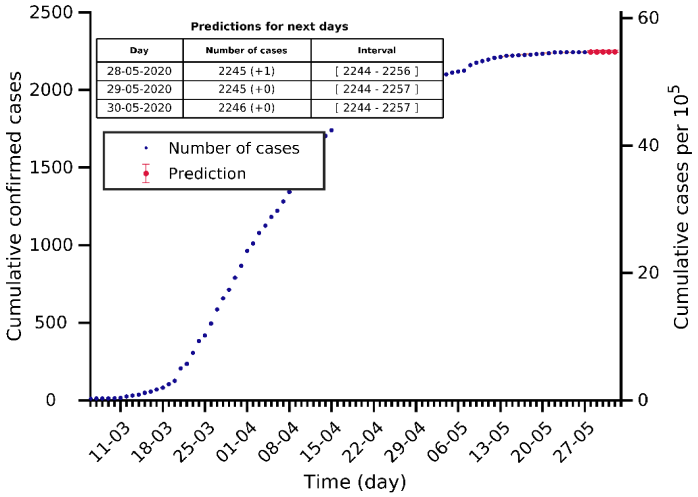


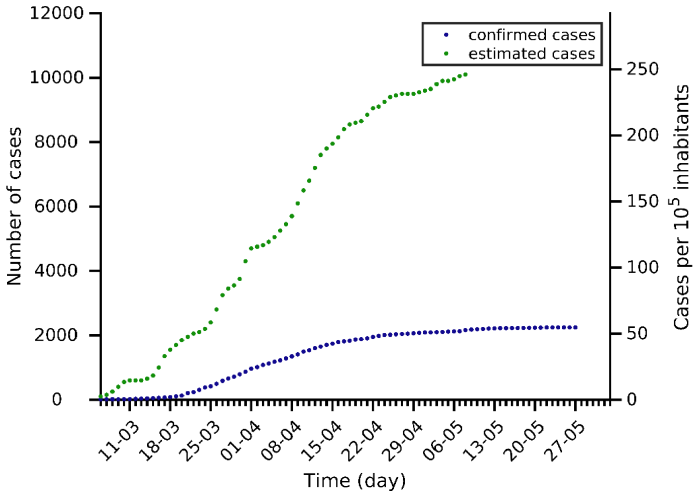


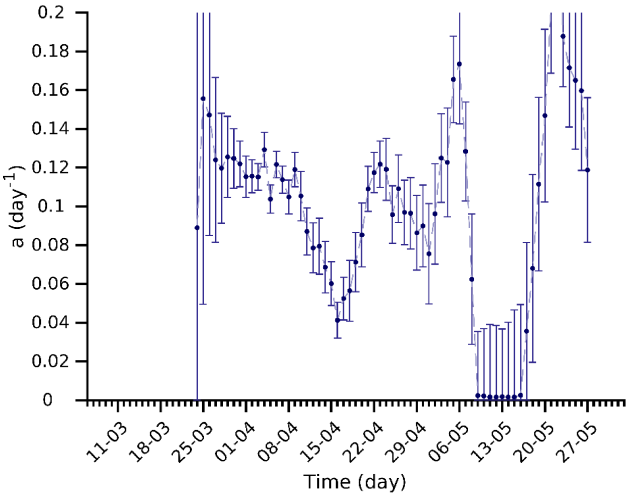


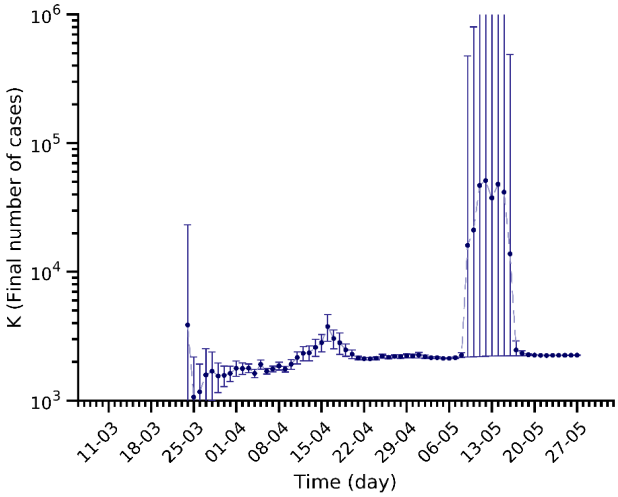


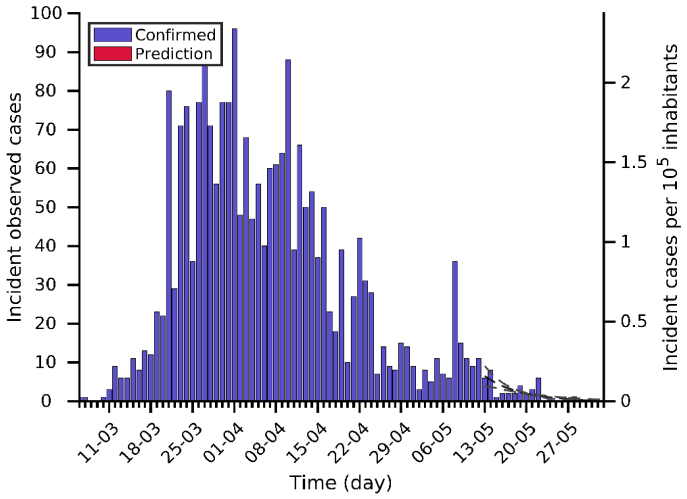
Croatia 27-05-2020. Population: 4.1M. Current cumulated incidence: $55/10^5$

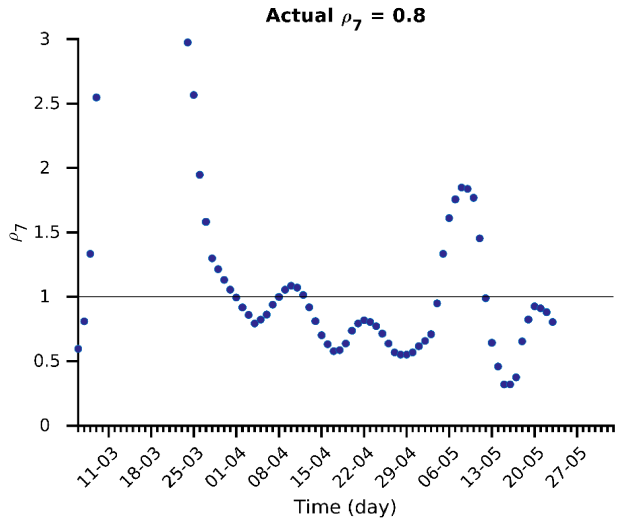


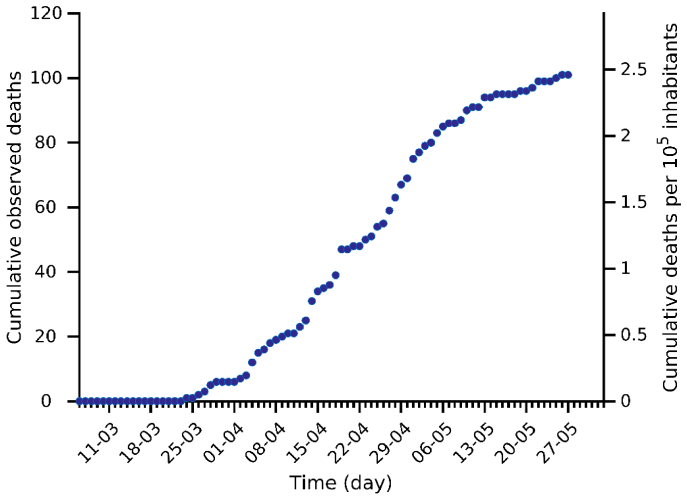


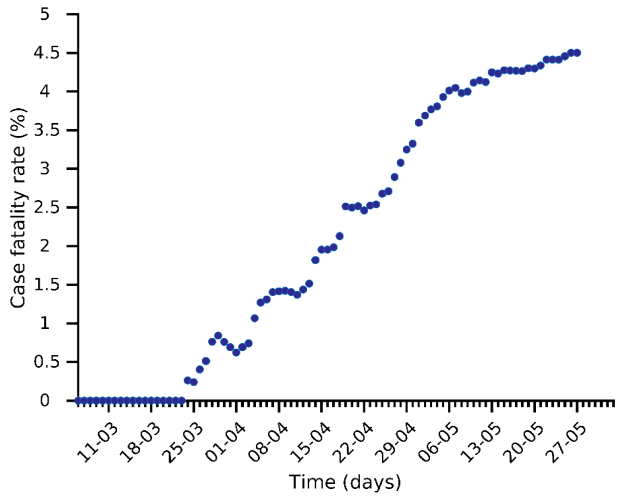




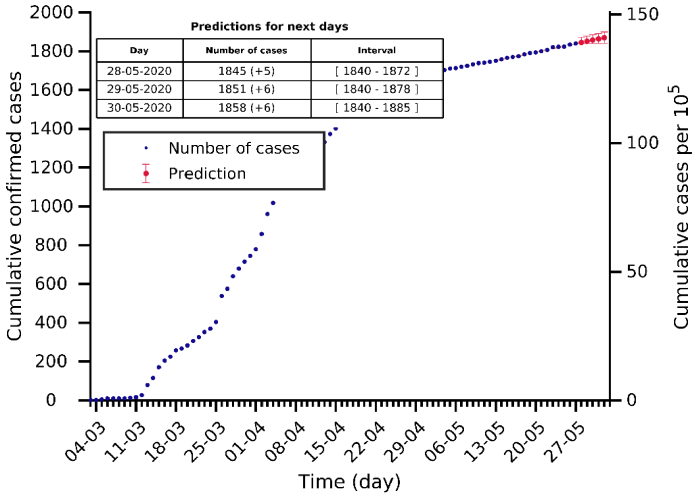


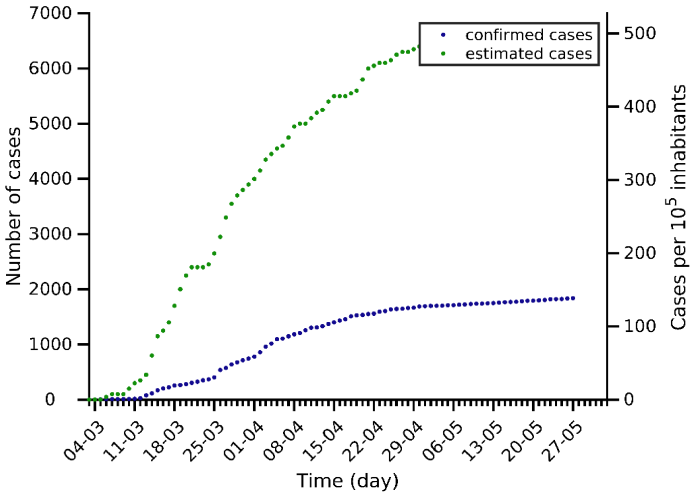


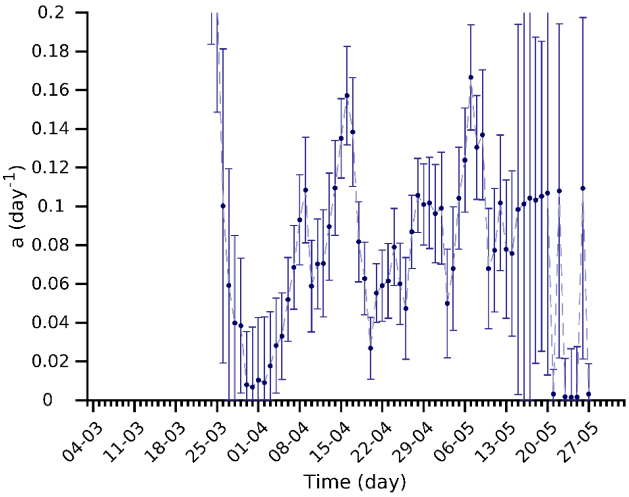


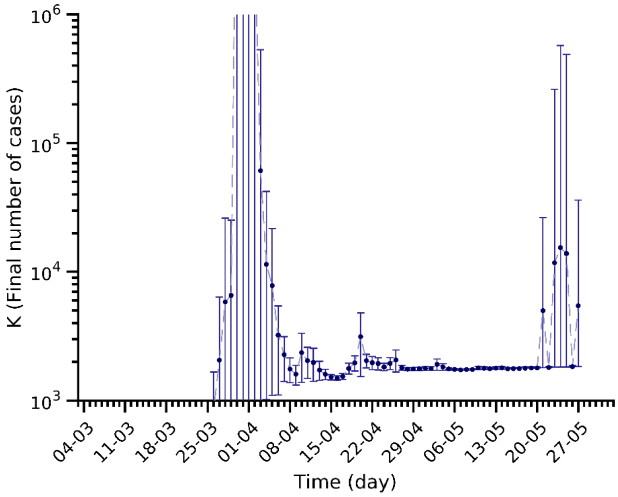


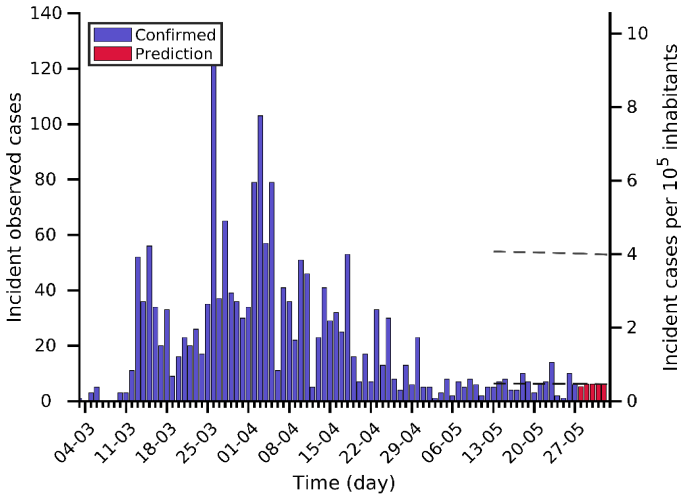
Estonia 27-05-2020. Population: 1.3M. Current cumulated incidence: 139/10^5

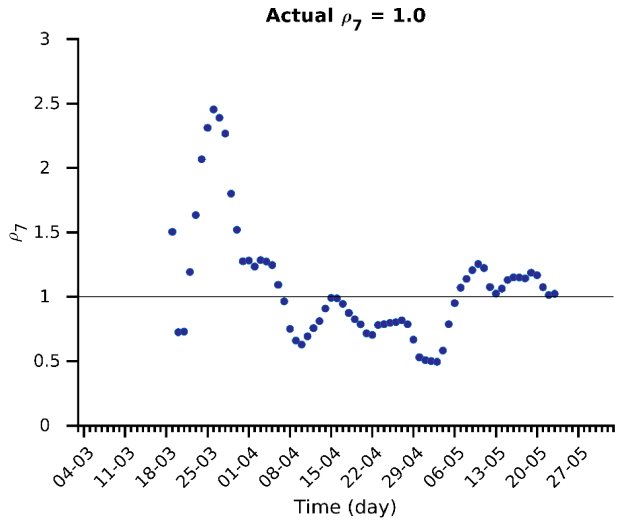


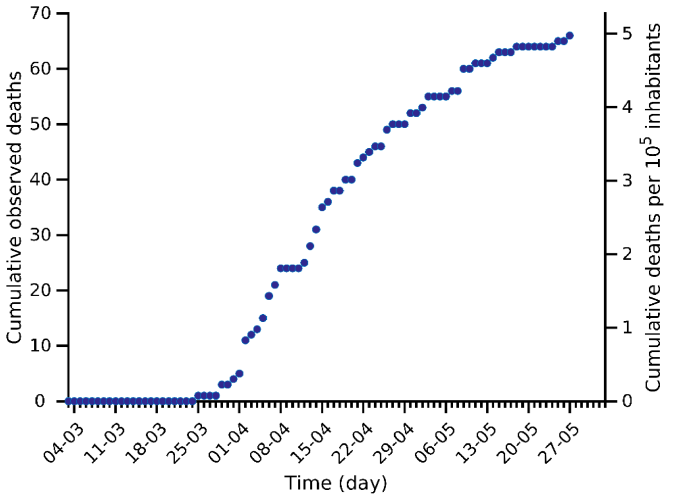


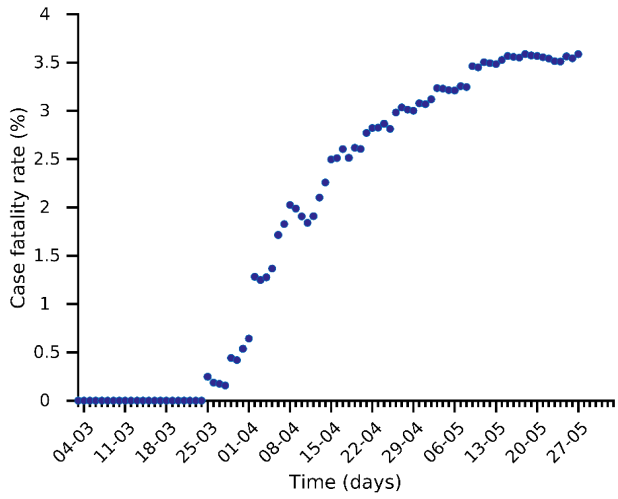




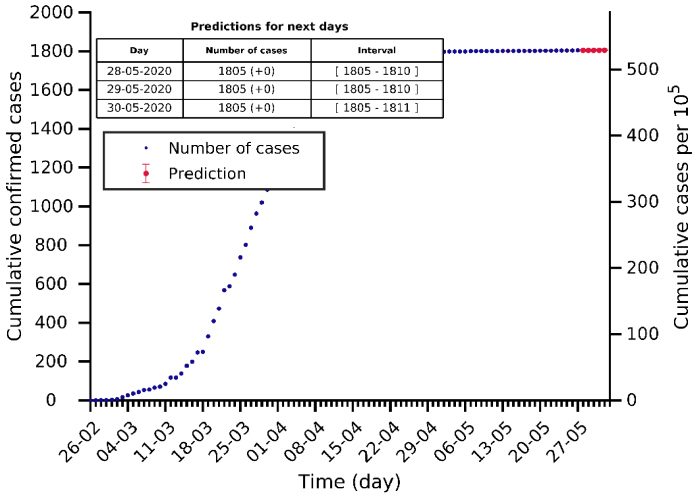


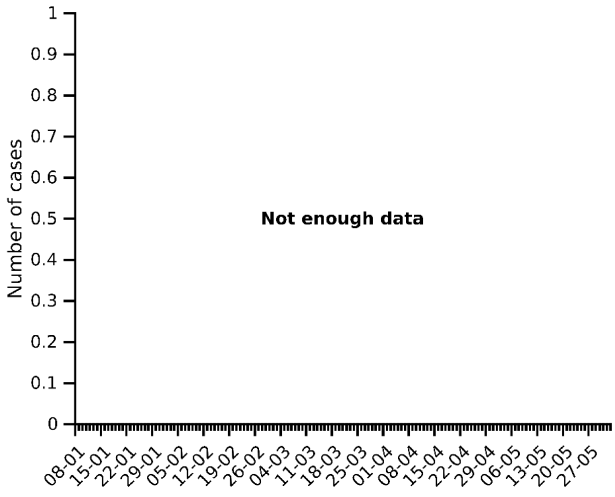


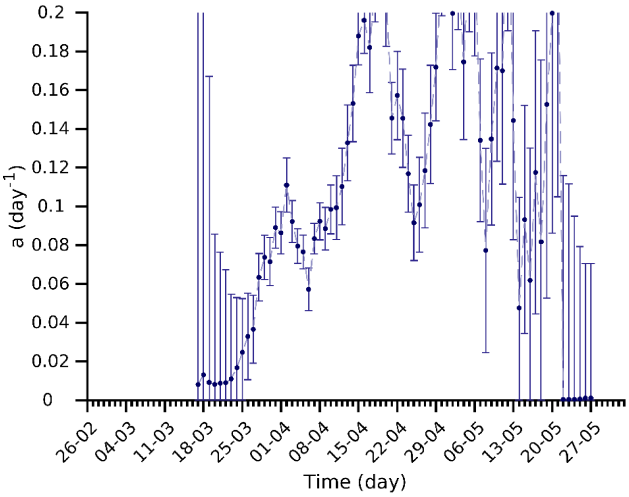


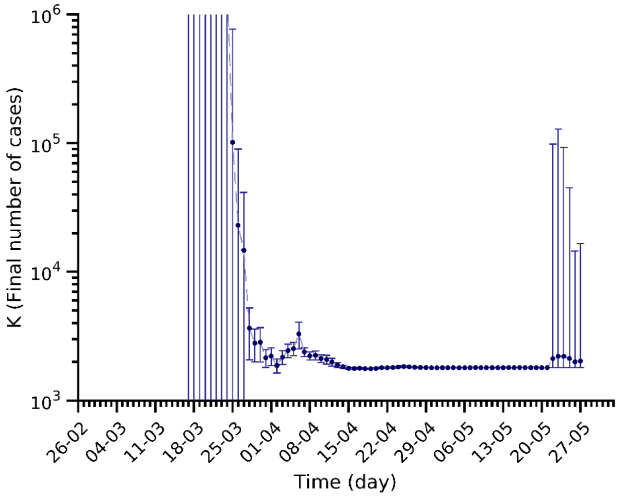


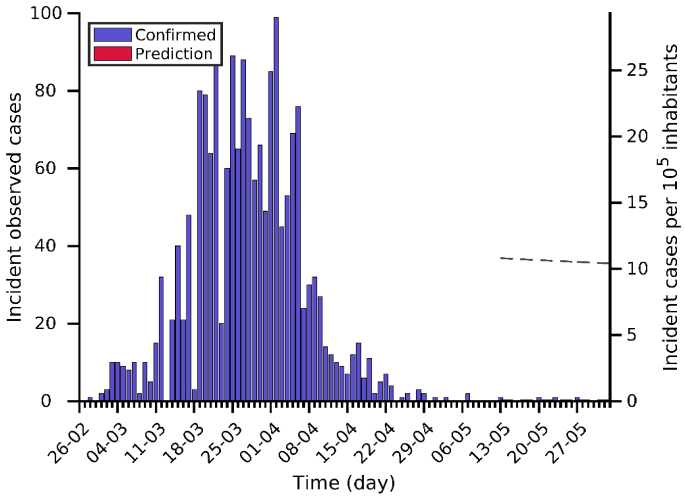
Iceland 27-05-2020. Population: 0.3M. Current cumulated incidence: 529/10^5

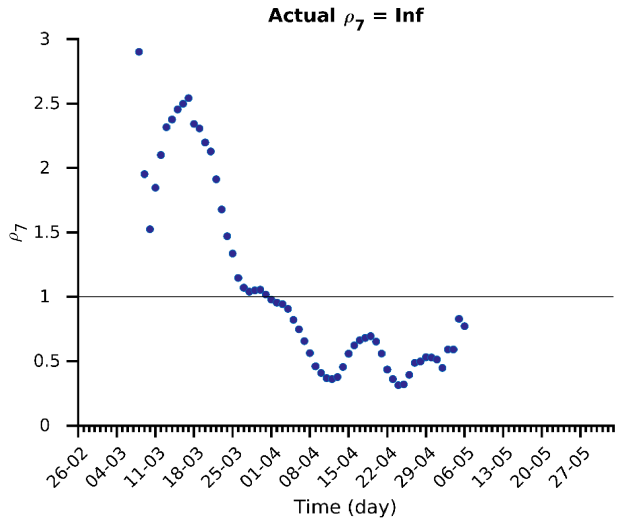


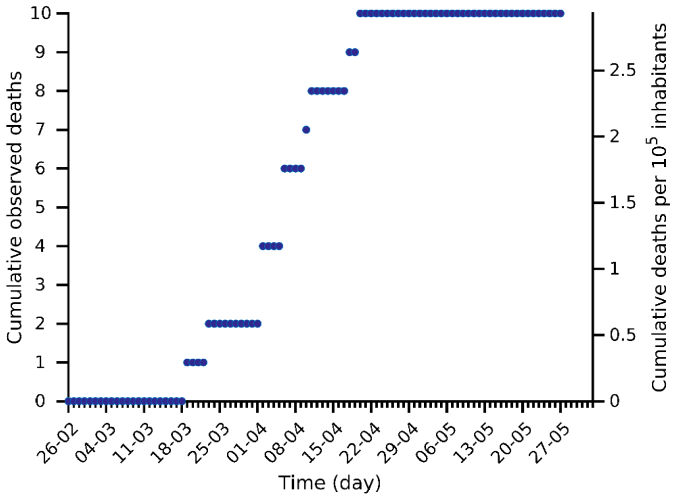


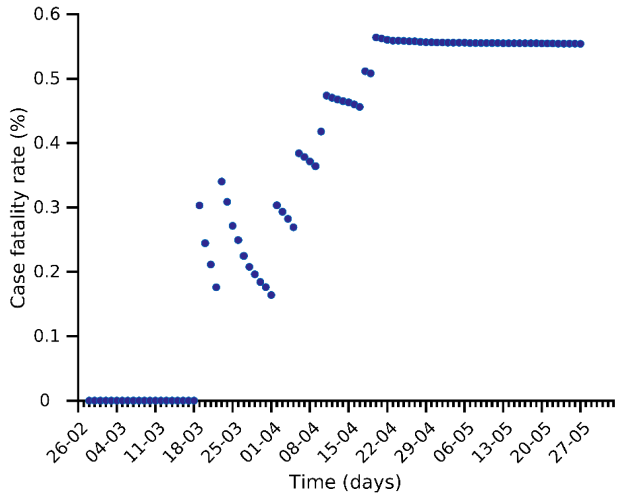




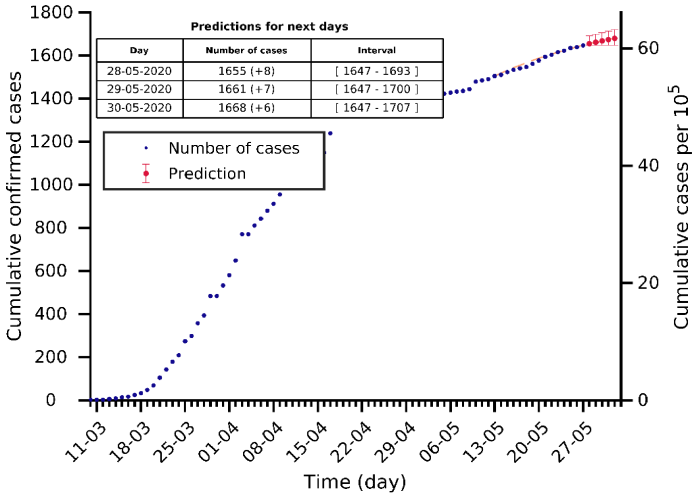


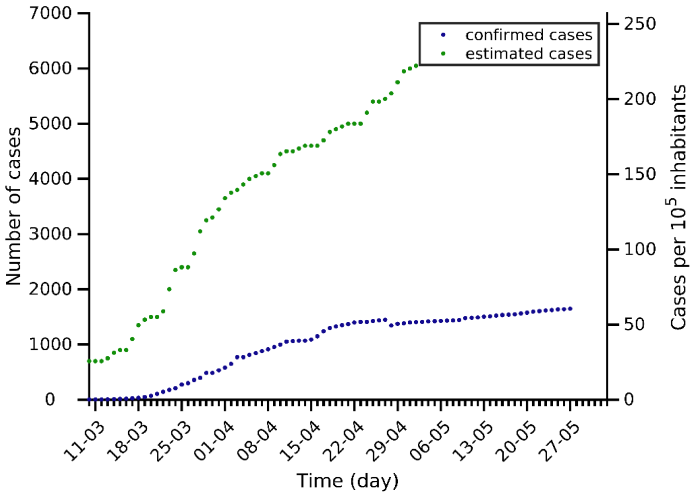


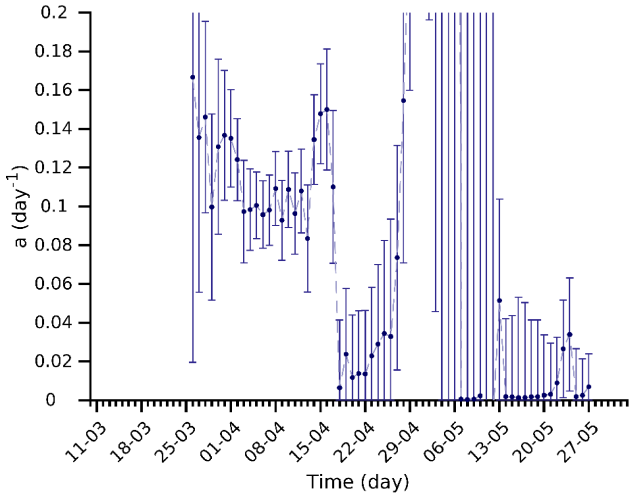


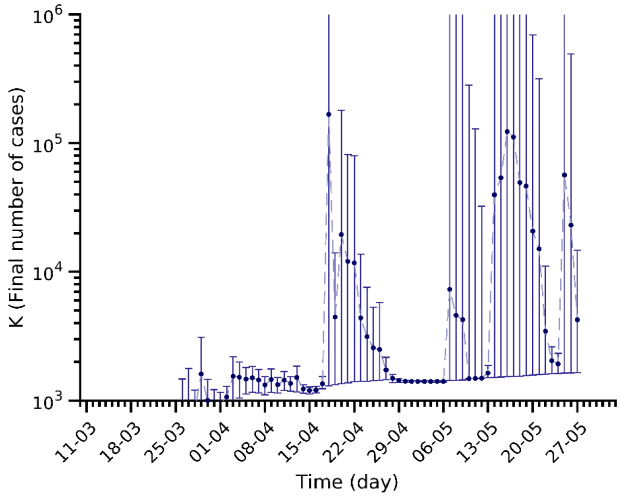


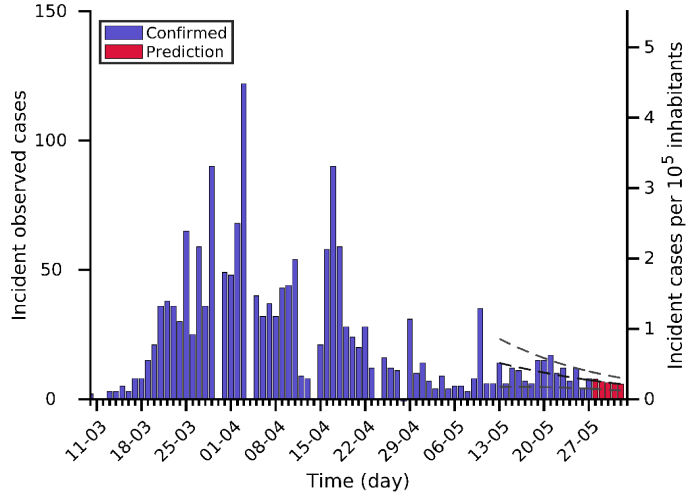
Lithuania 27-05-2020. Population: 2.7M. Current cumulated incidence: 61/10^5

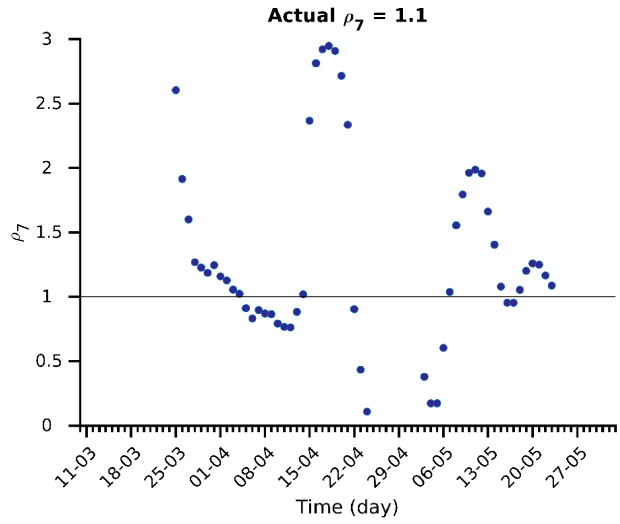


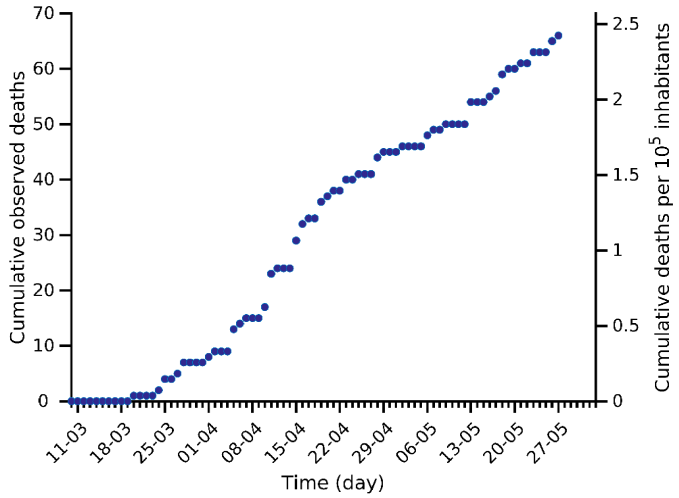


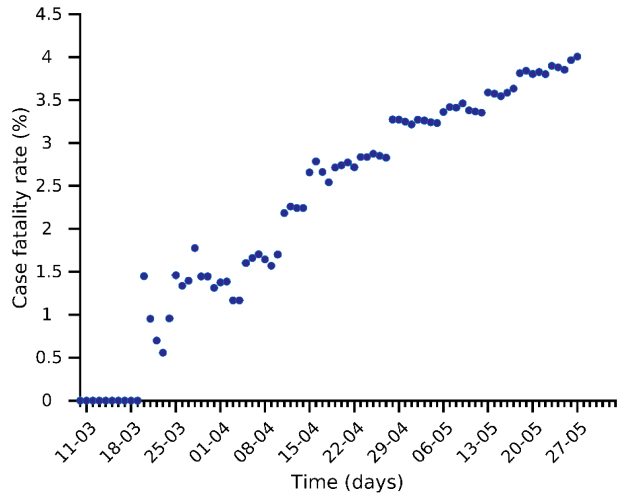




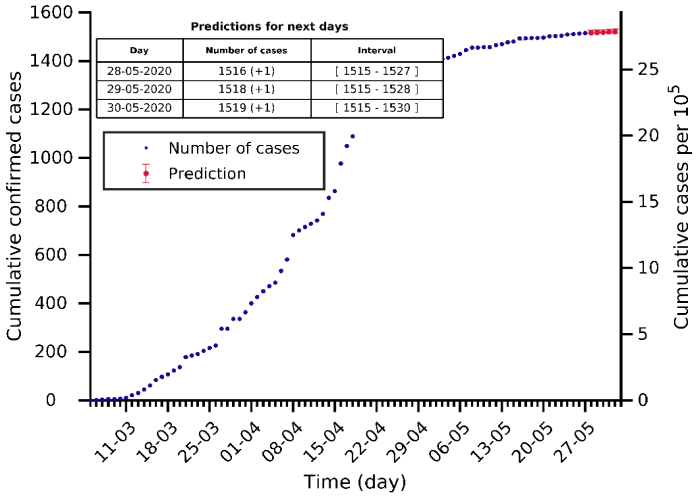


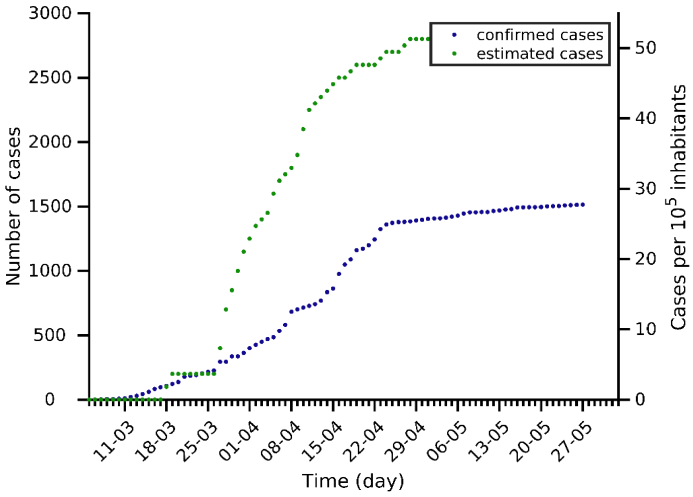


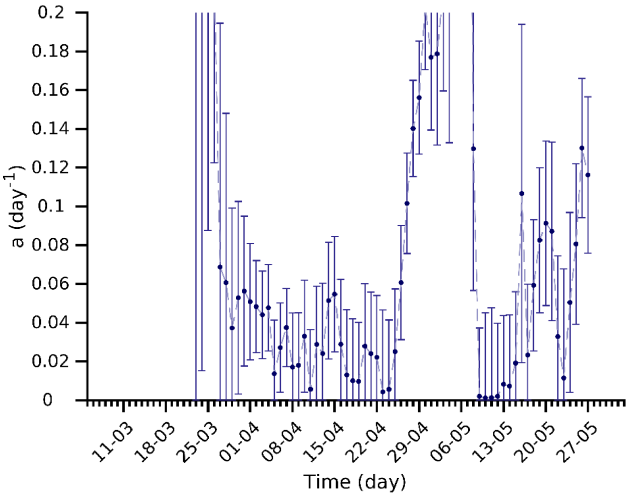


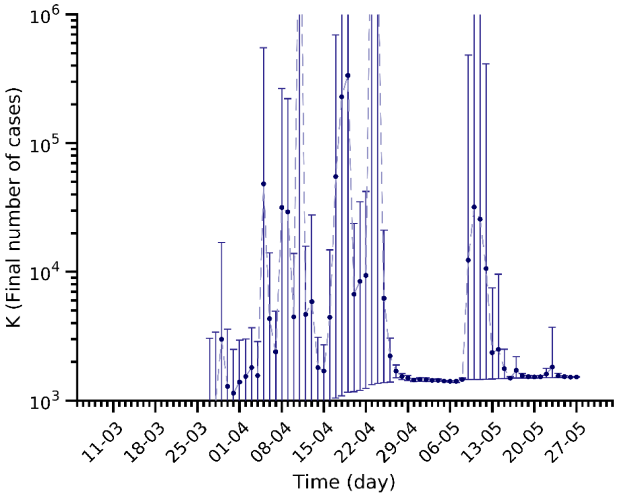


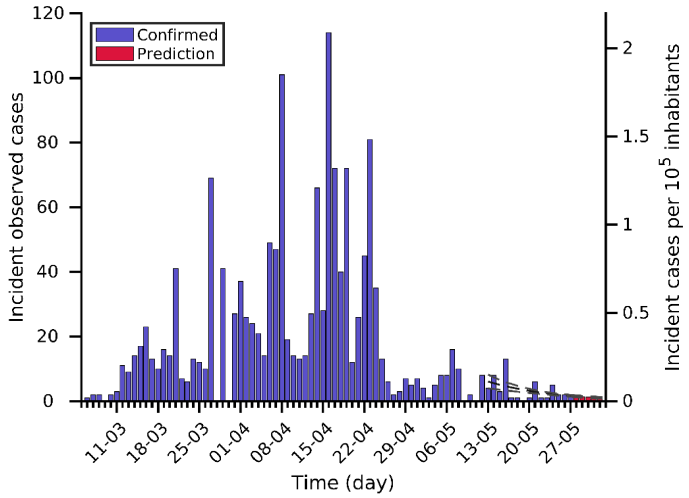
Slovakia 27-05-2020. Population: 5.5M. Current cumulated incidence: 28/10^5

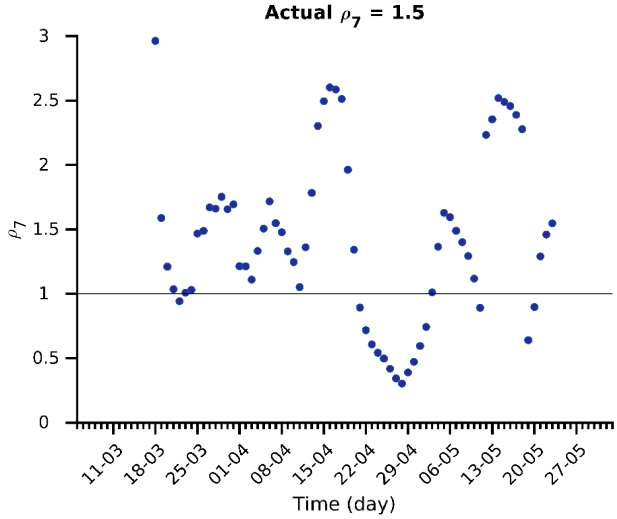


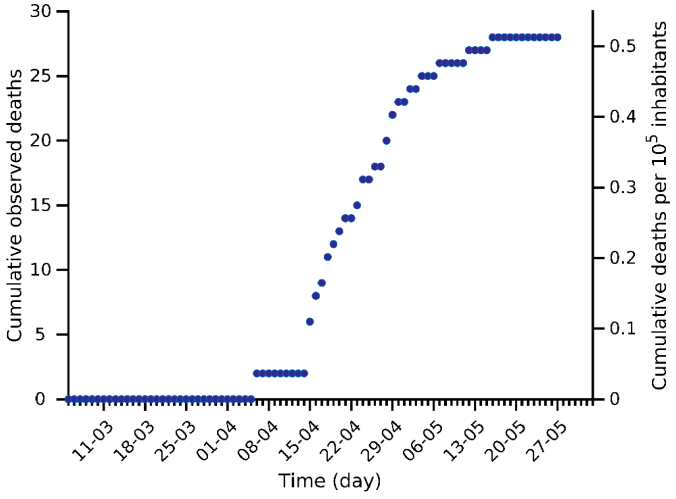


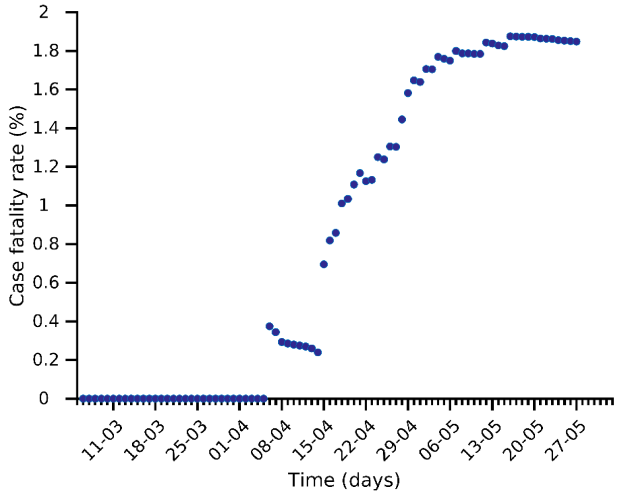




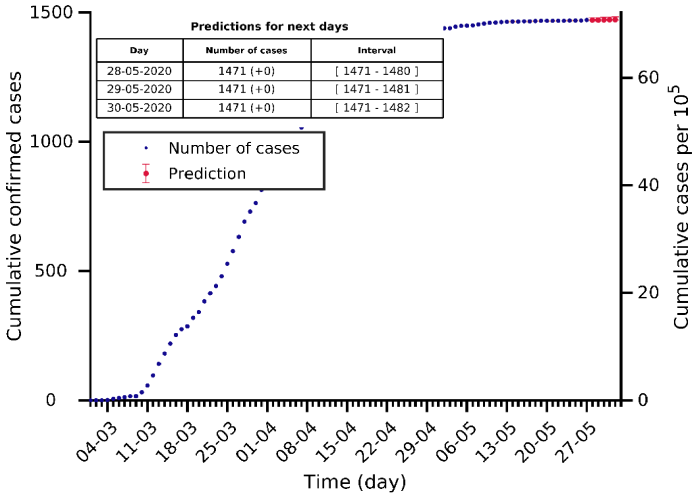


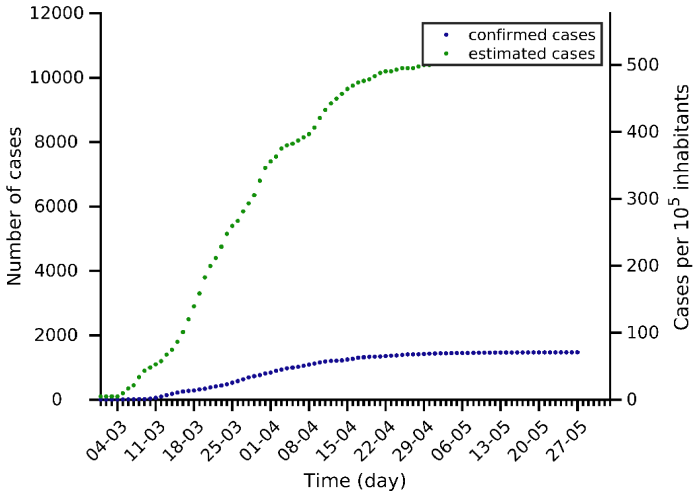


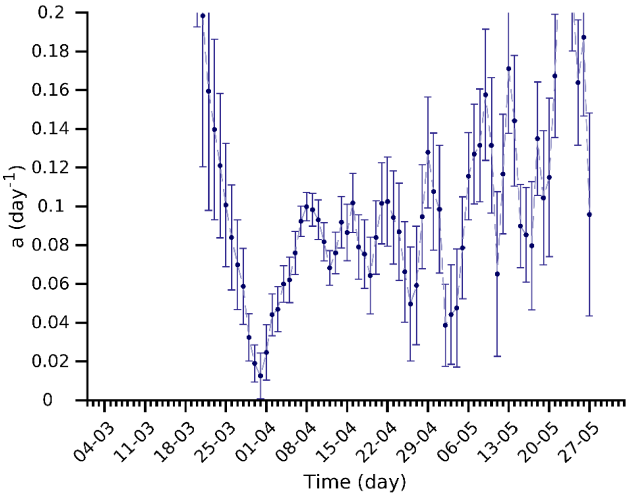


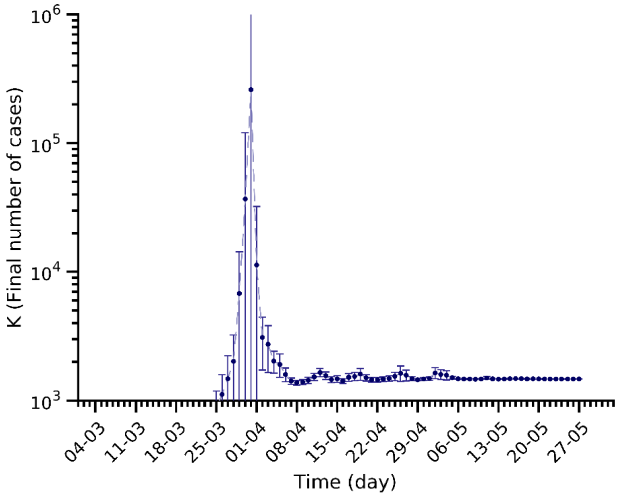


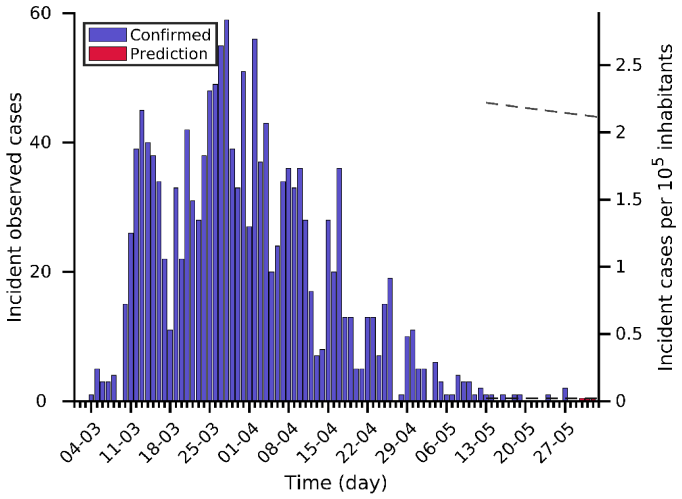
Slovenia 27-05-2020. Population: 2.1M. Current cumulated incidence: 71/10^5

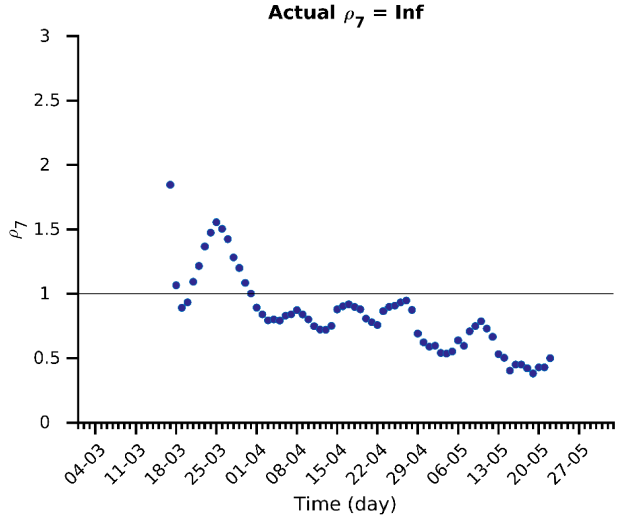


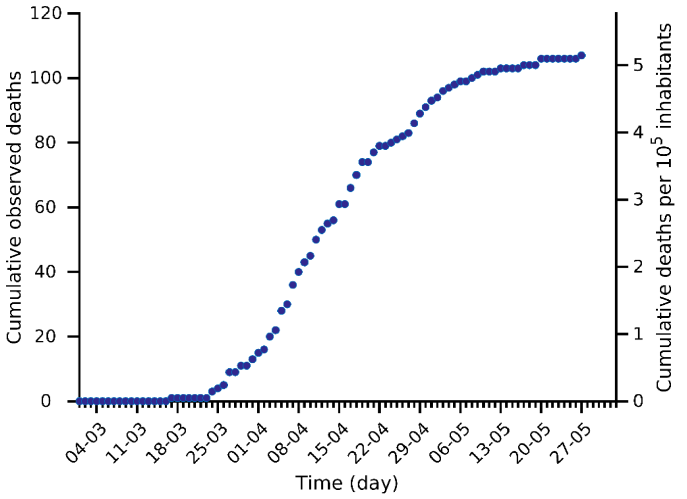


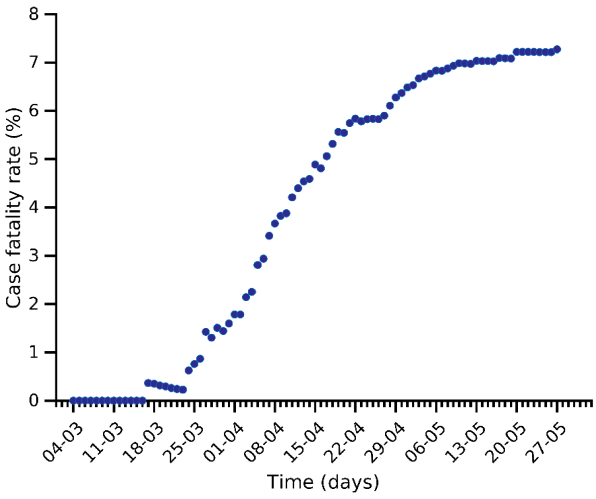




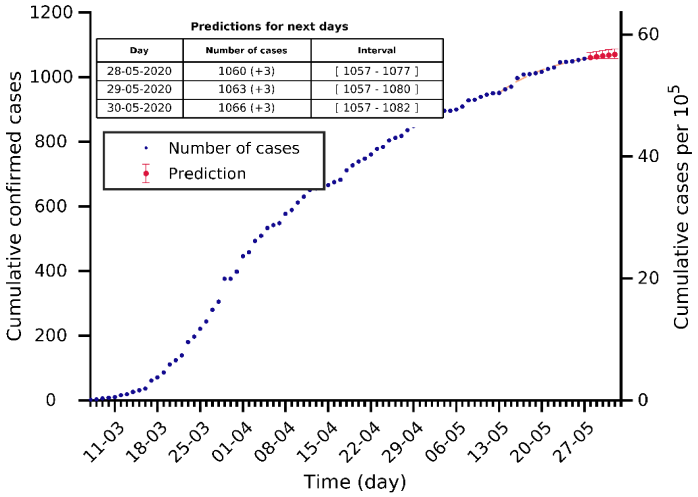


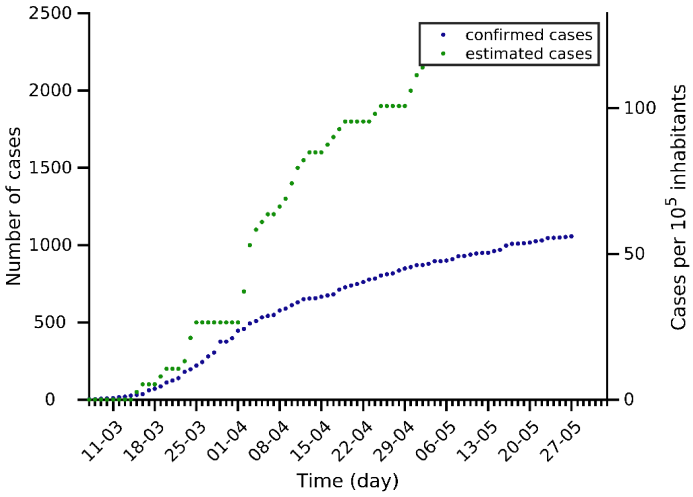


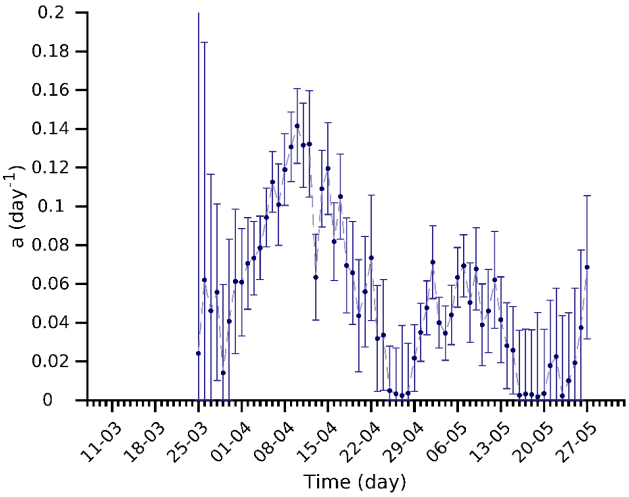


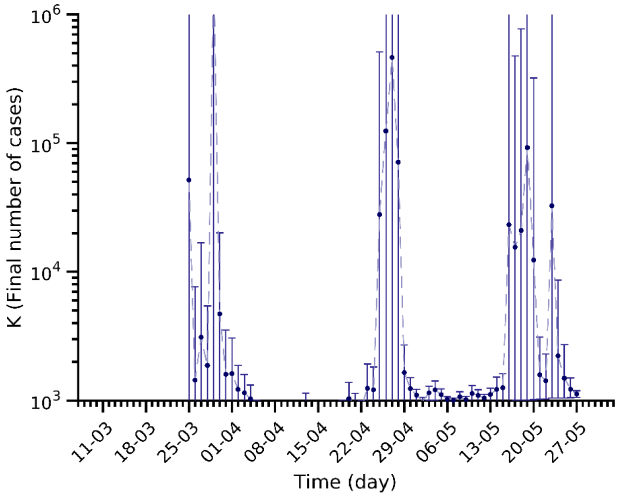


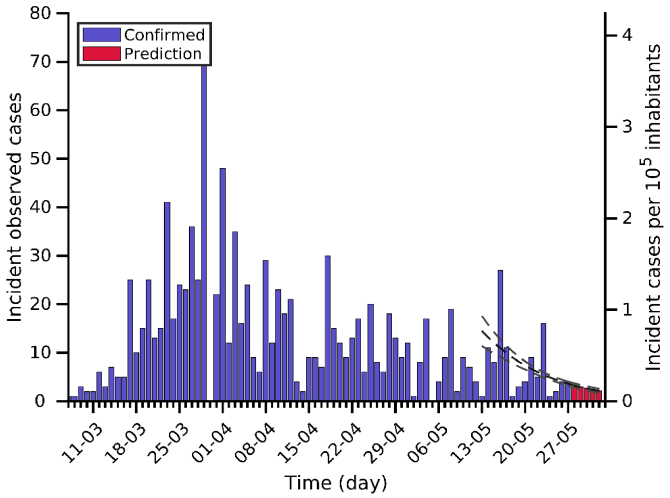
Latvia 27-05-2020. Population: 1.9M. Current cumulated incidence: 56/10^5

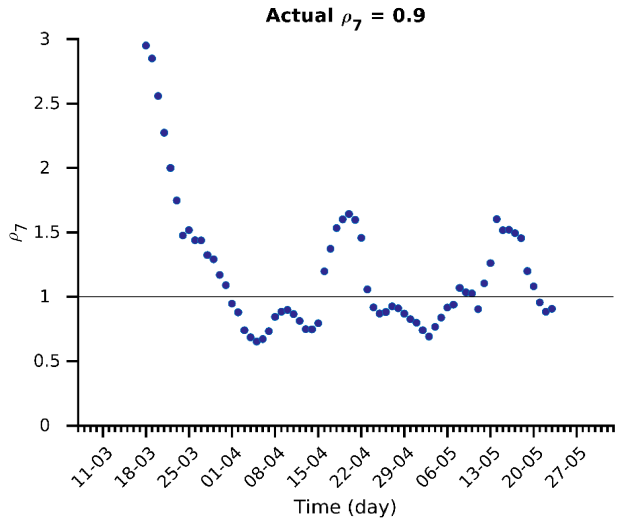


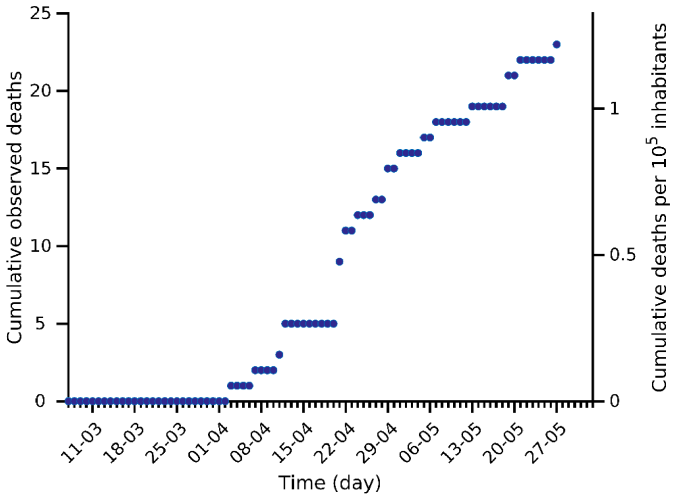


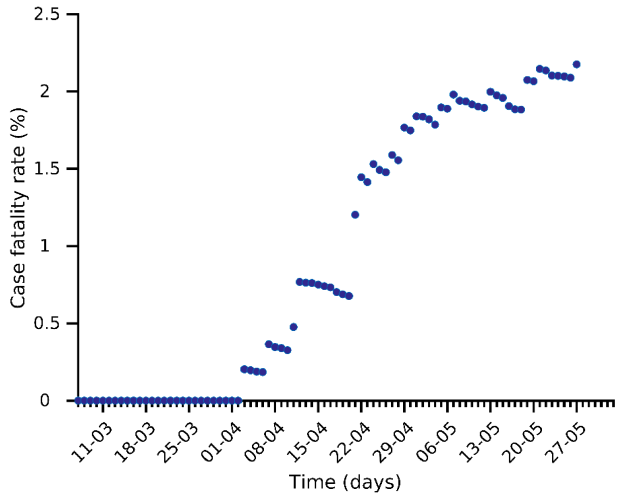




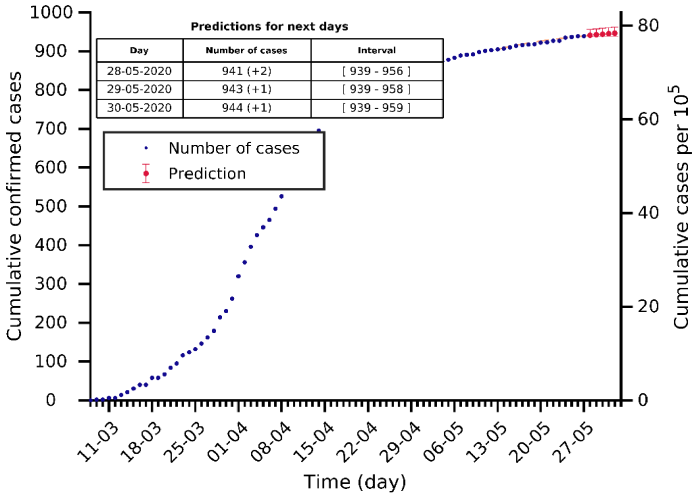


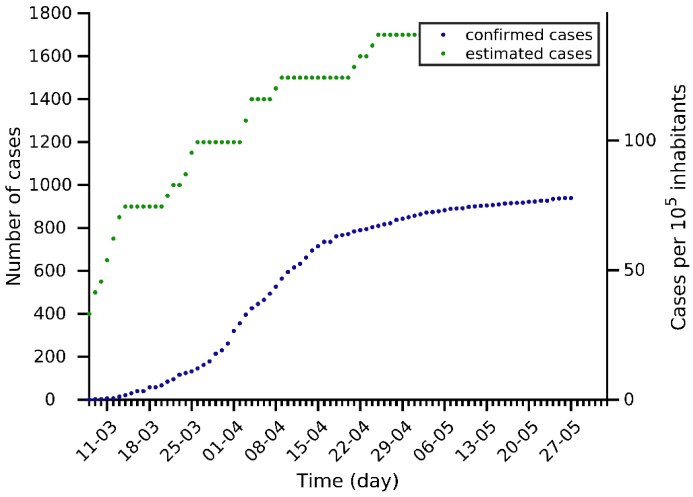


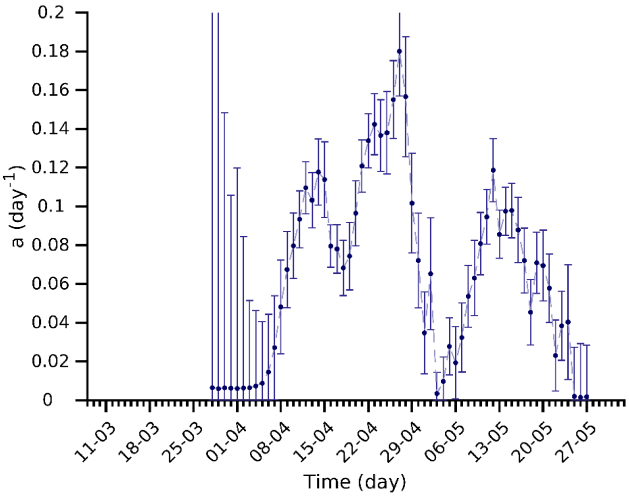


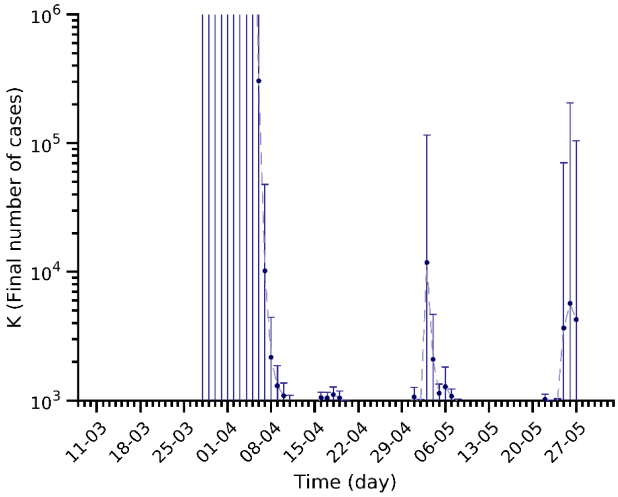


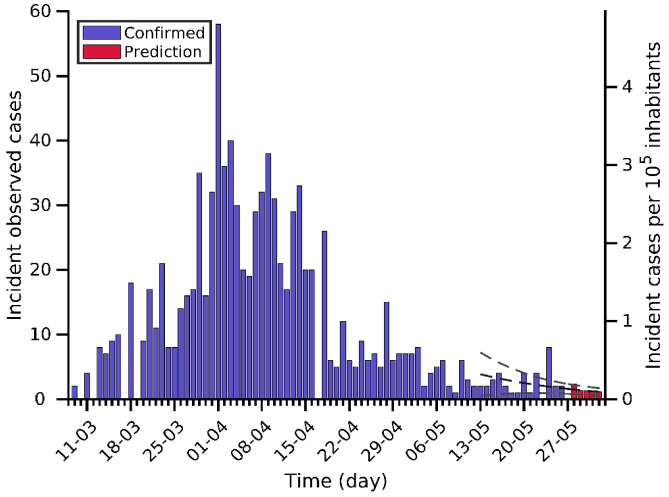
Cyprus 27-05-2020. Population: 1.2M. Current cumulated incidence: $78/10^5$

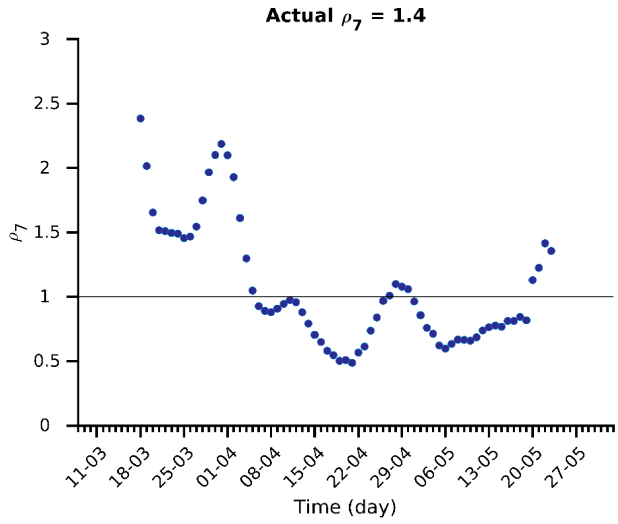


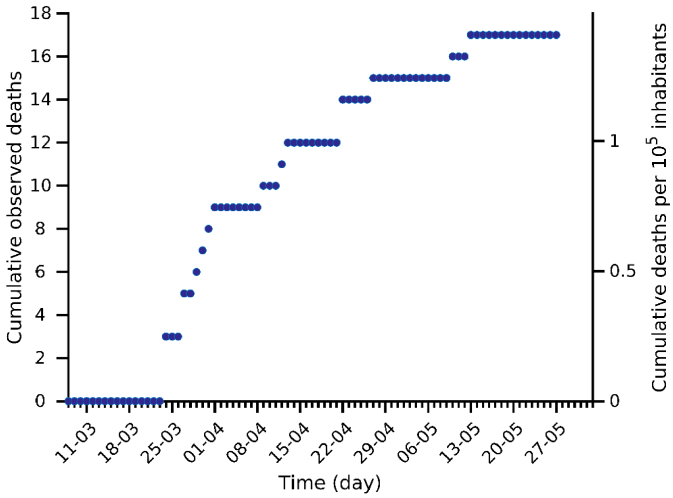


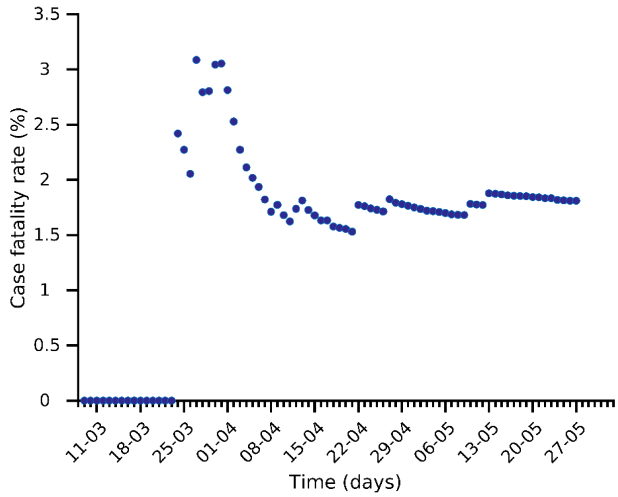




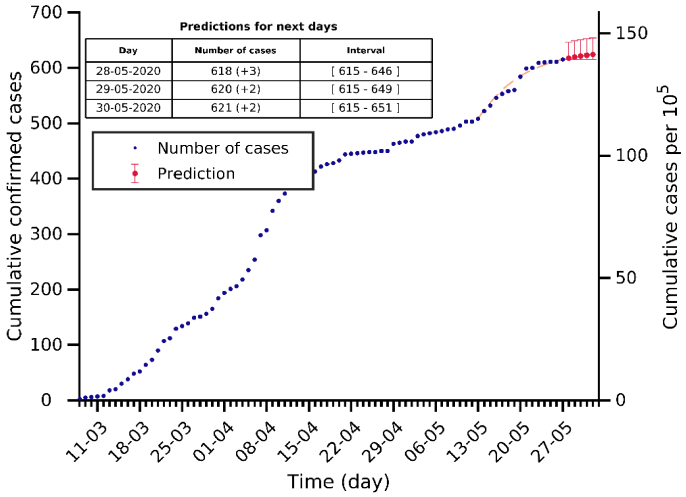


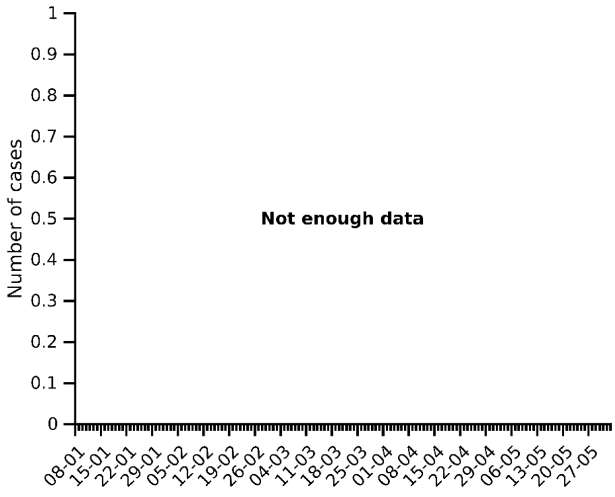


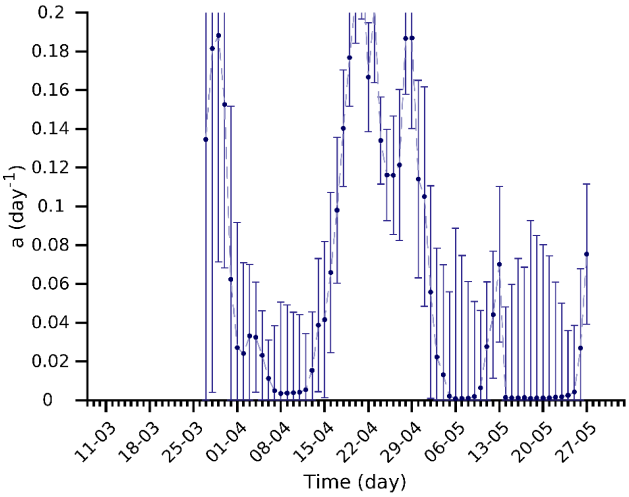


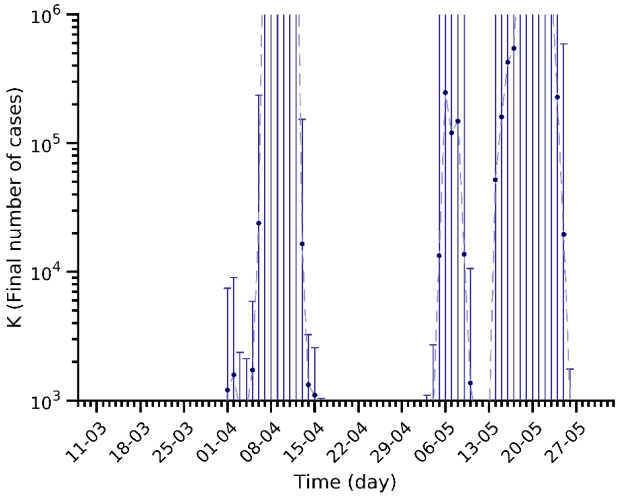


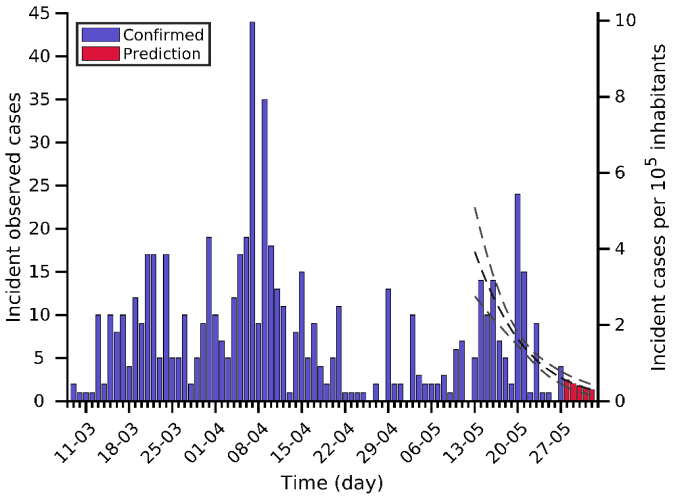
Malta 27-05-2020. Population: 0.4M. Current cumulated incidence: 139/10^5

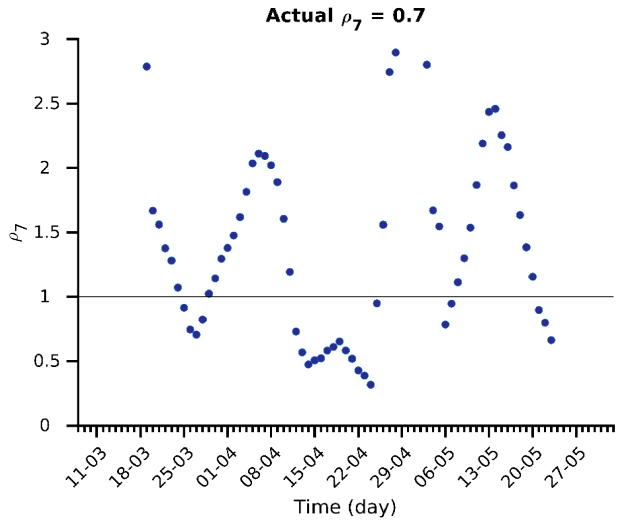


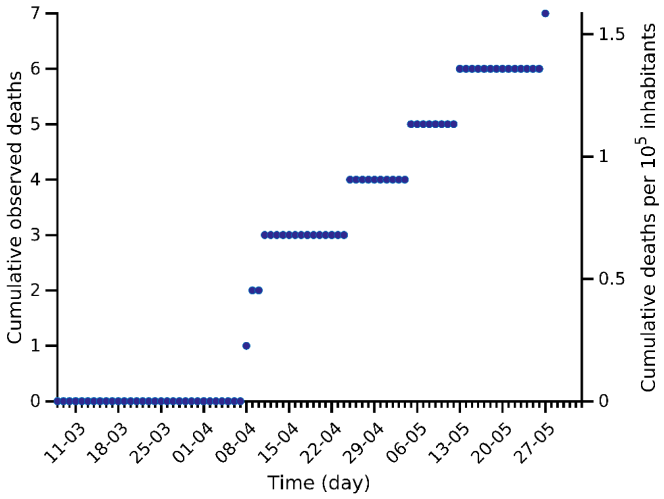


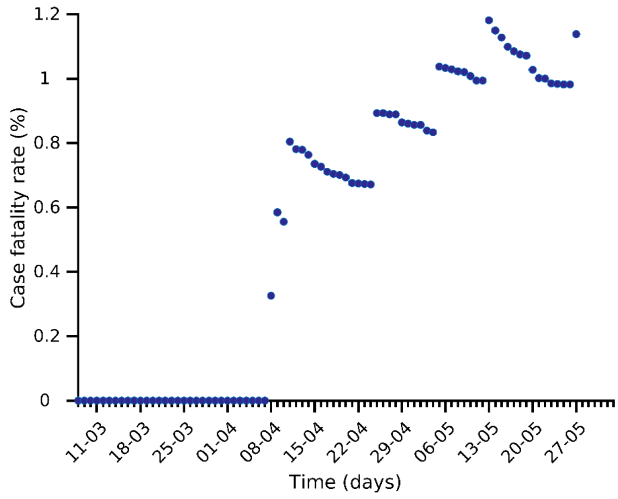








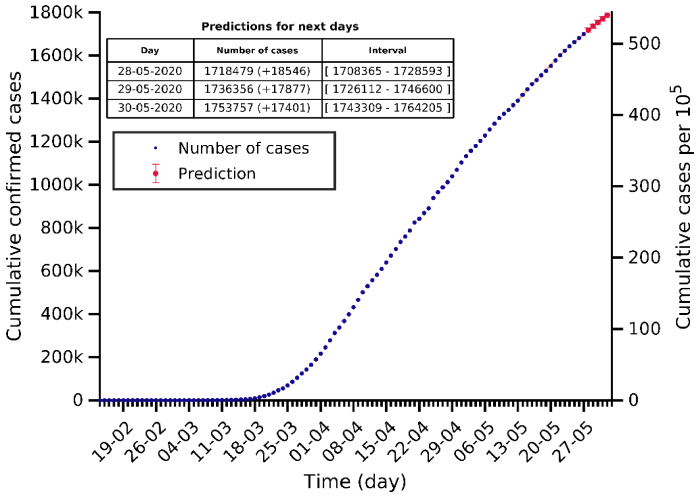


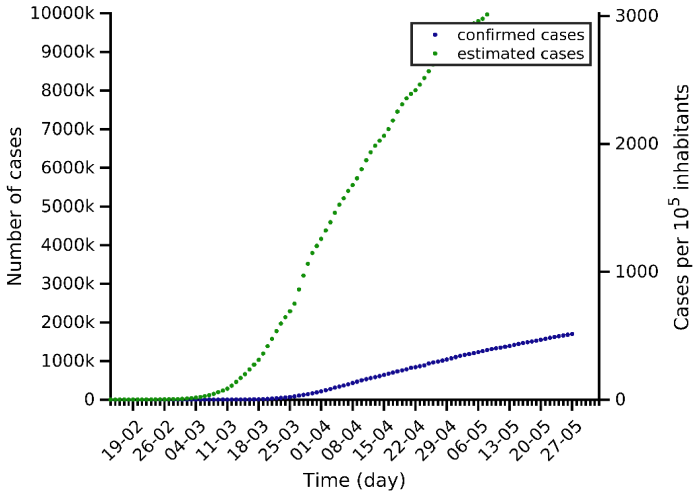


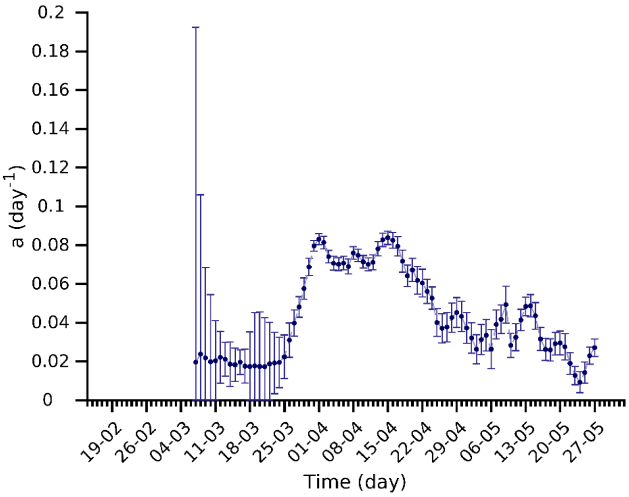
(2) Analysis and prediction of COVID-19 for other countries

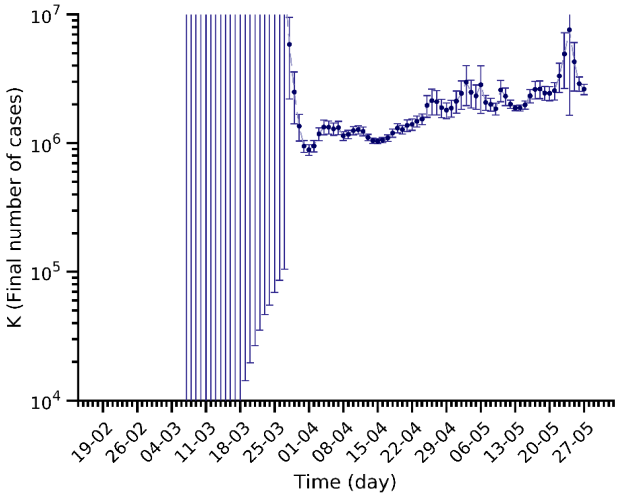
Data obtained from https://www.ecdc.europa.eu/en/geographical-distribution-2019-ncov-cases

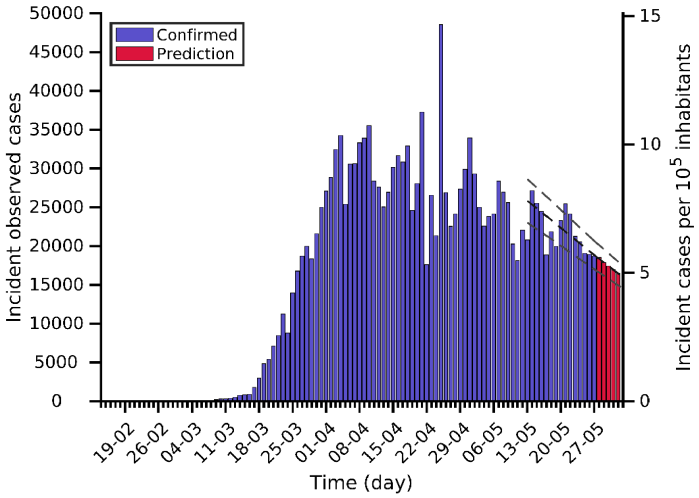
USA 27-05-2020. Population: 331.0M. Current cumulated incidence: 514/10⁵

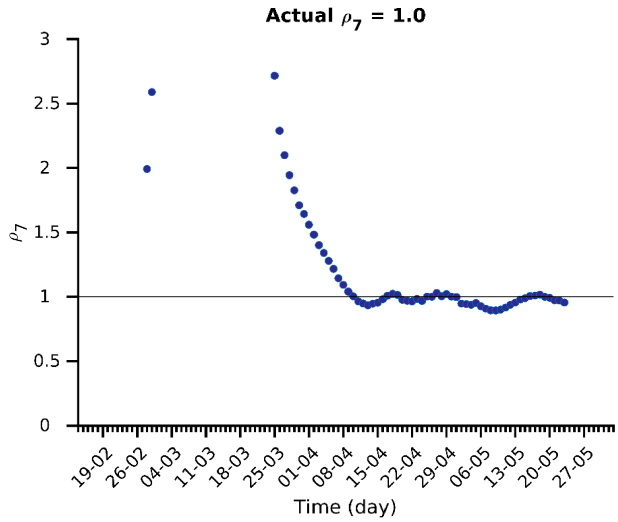


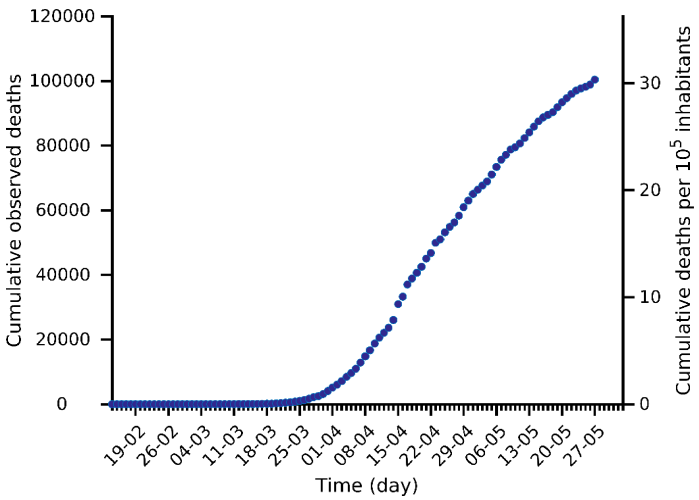


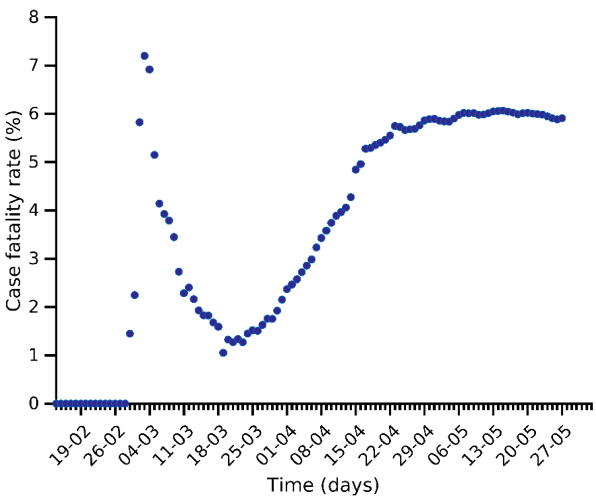




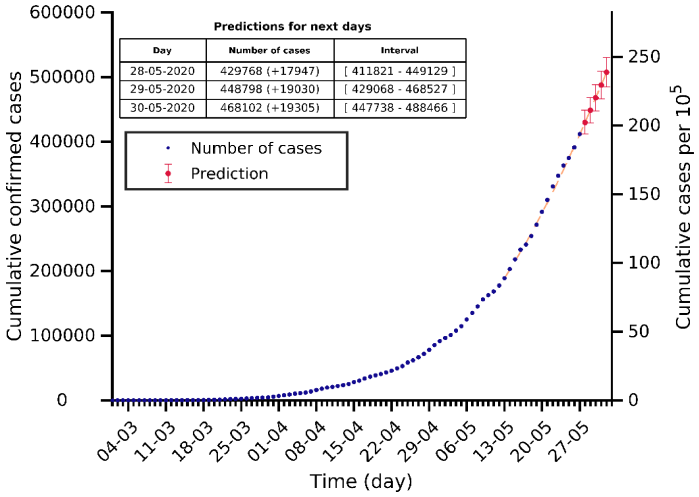


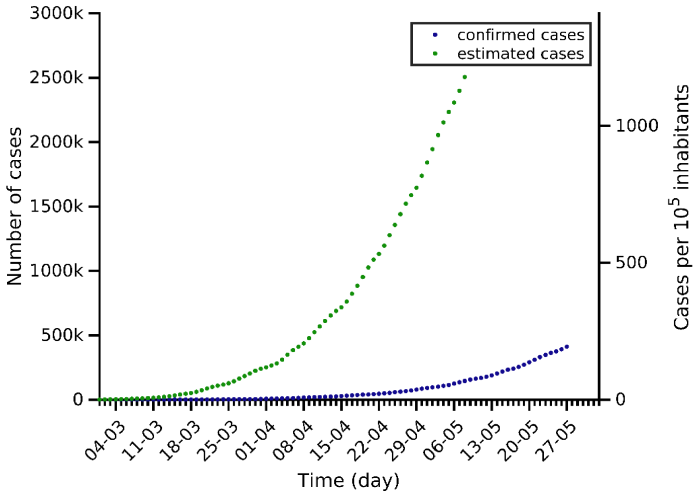


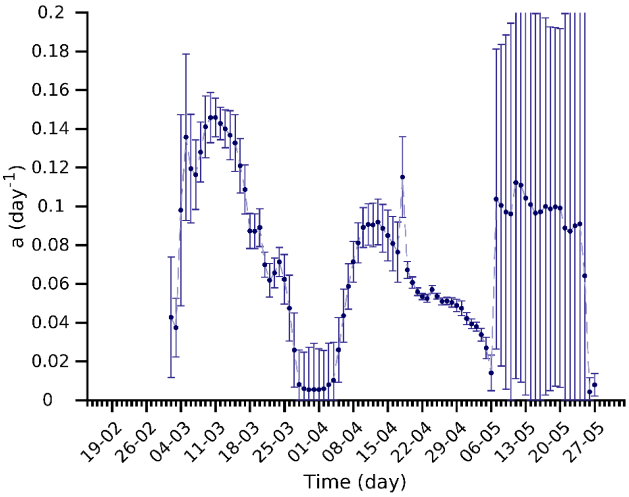


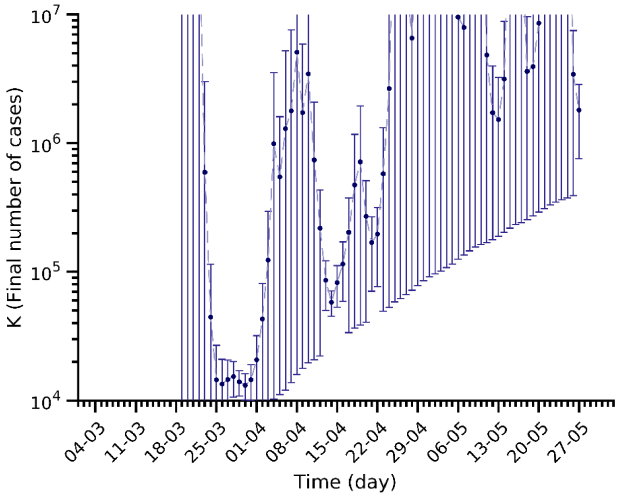


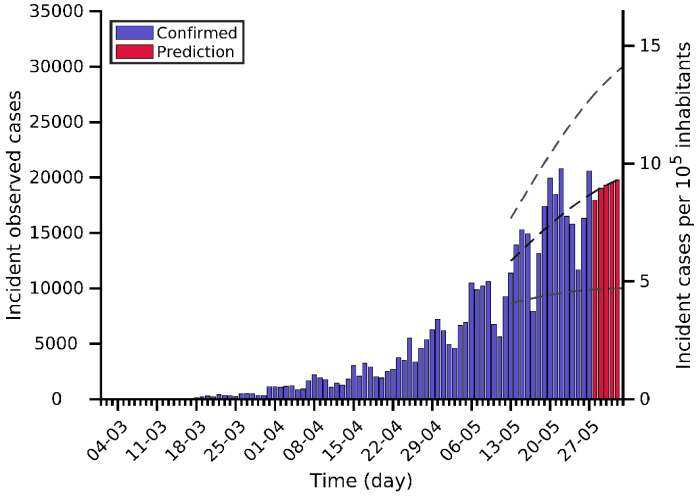
Brazil 27-05-2020. Population: 212.6M. Current cumulated incidence: 194/10^5

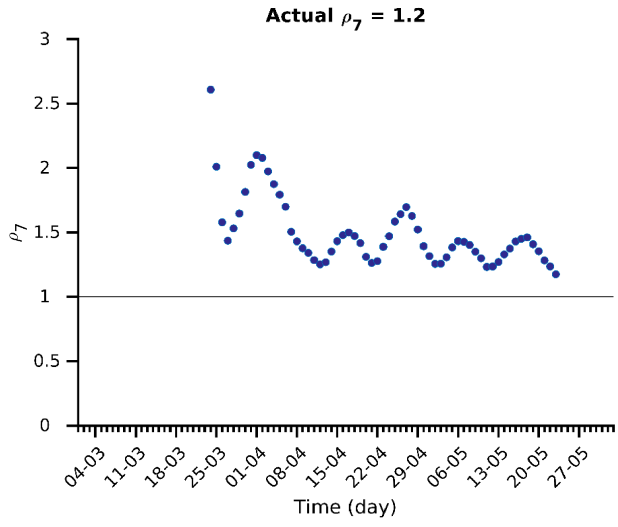


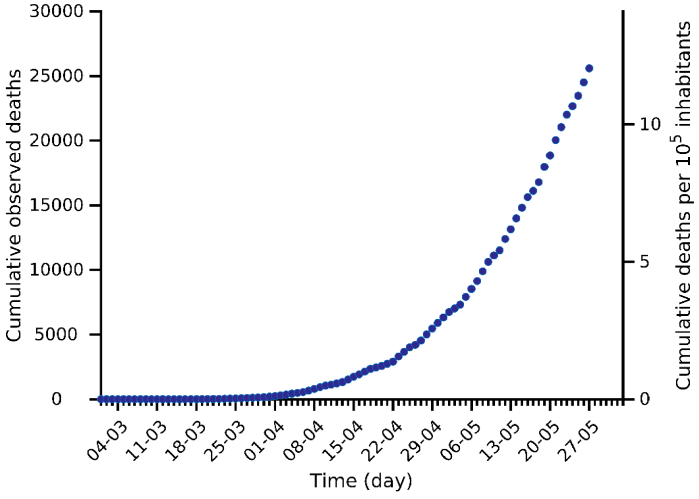


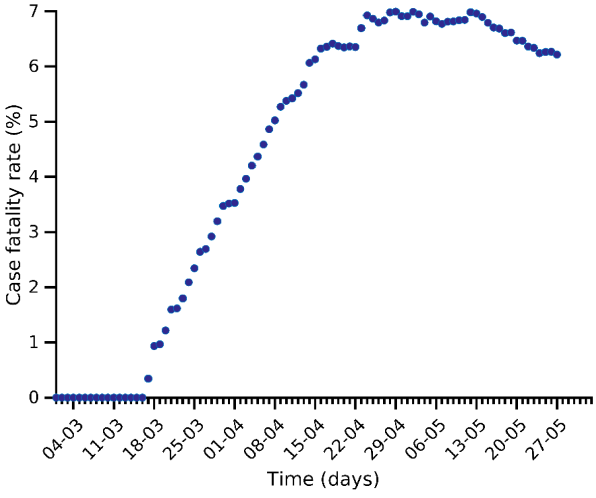




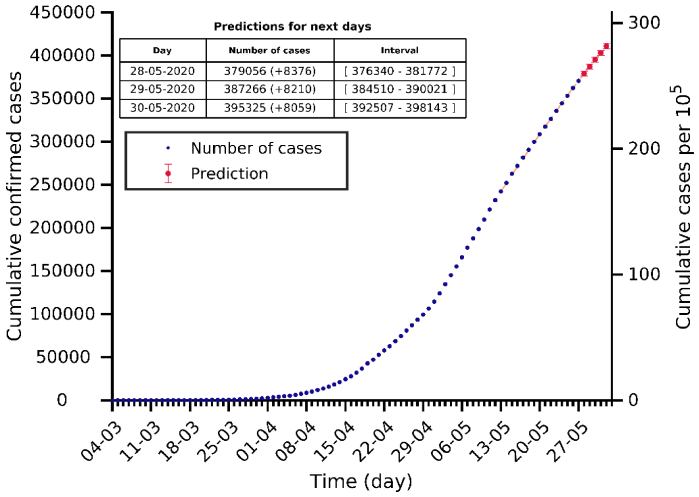


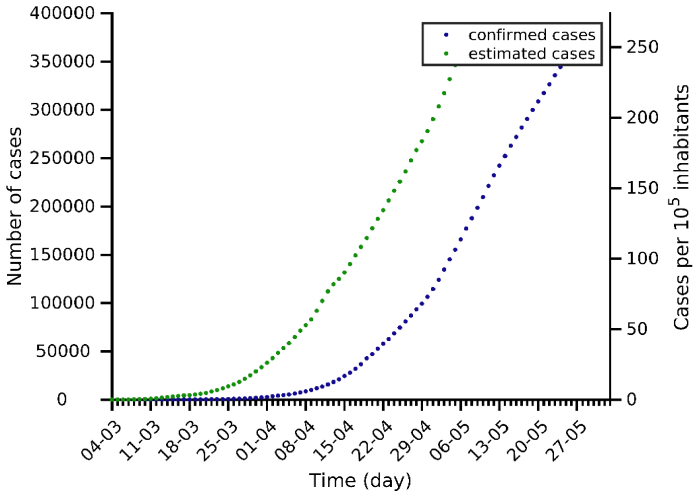


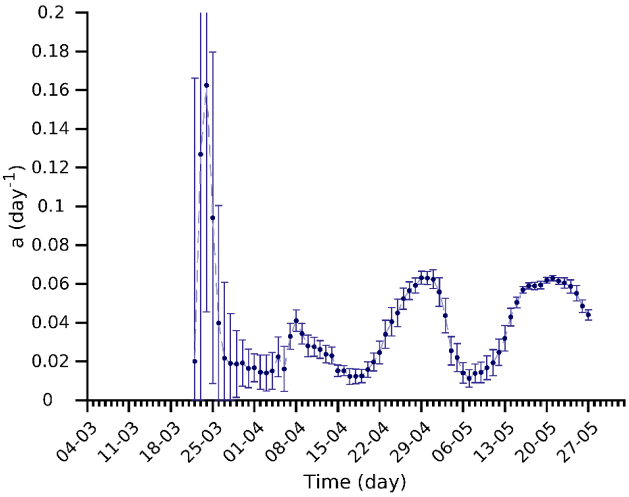


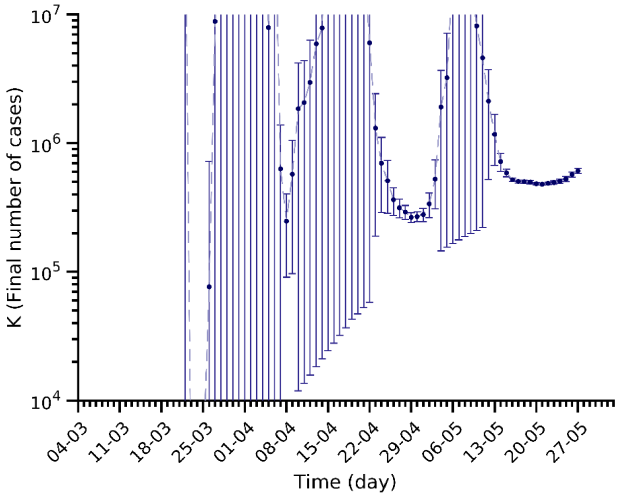


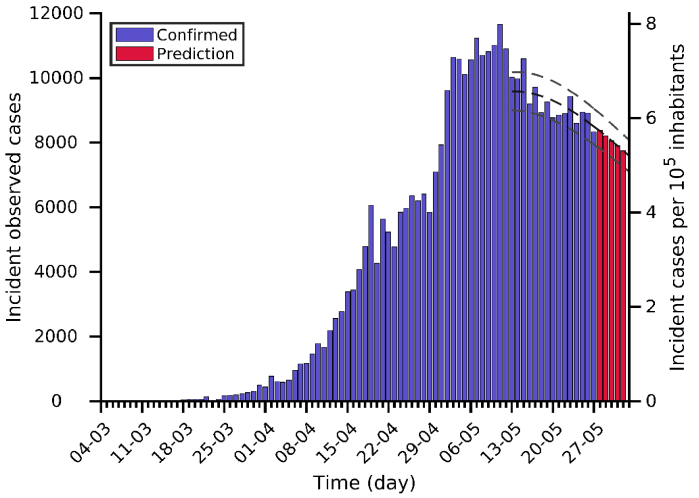
Russia 27-05-2020. Population: 145.9M. Current cumulated incidence: 254/10⁵

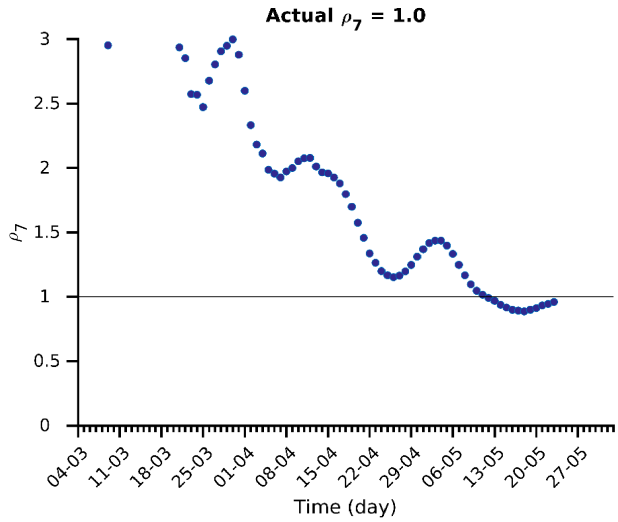


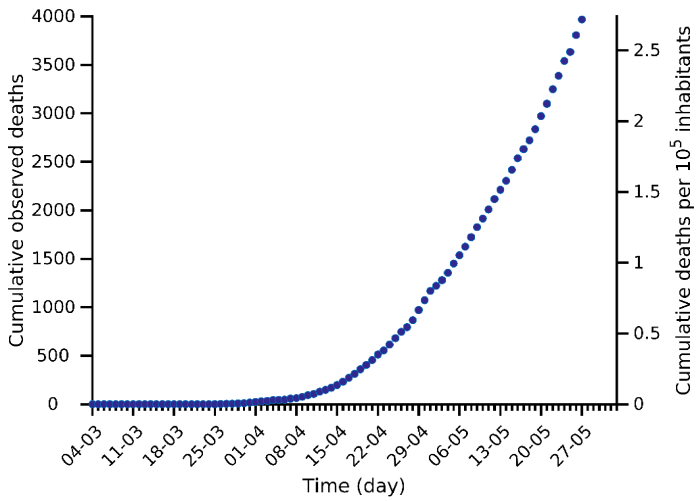


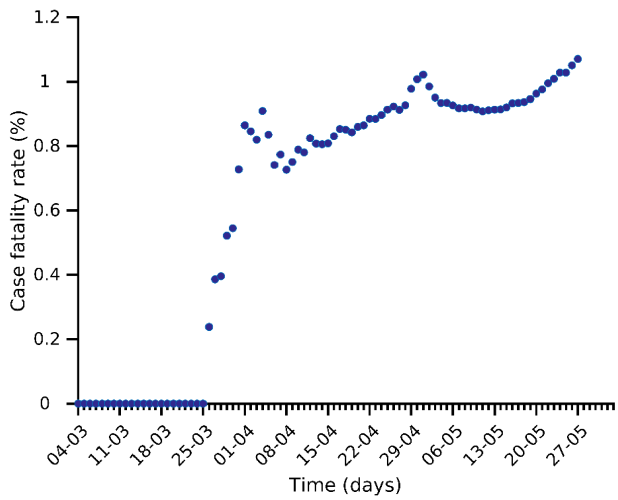




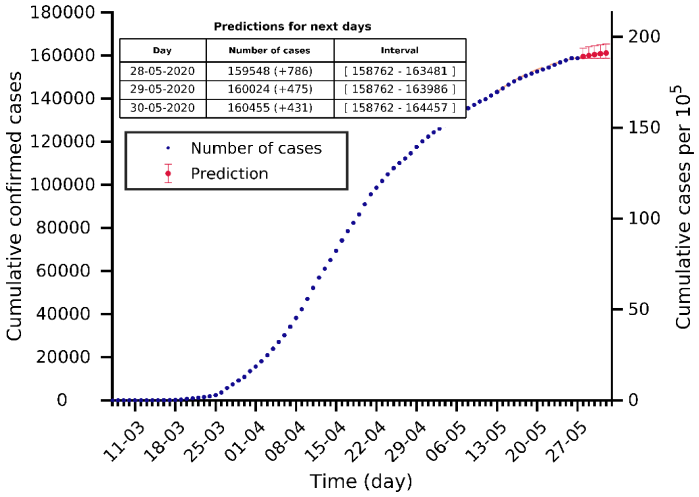


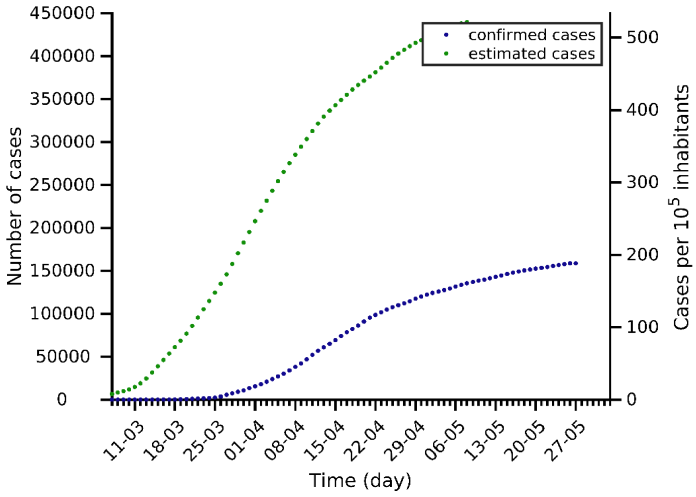


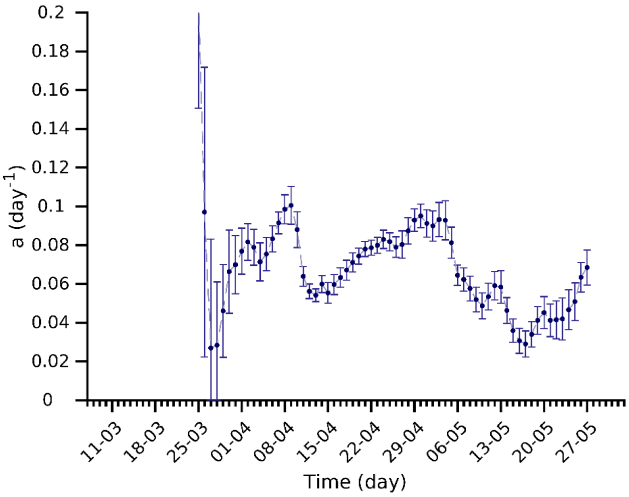


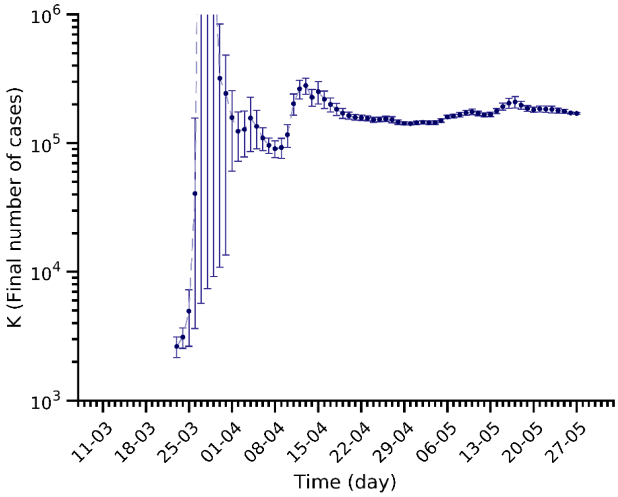


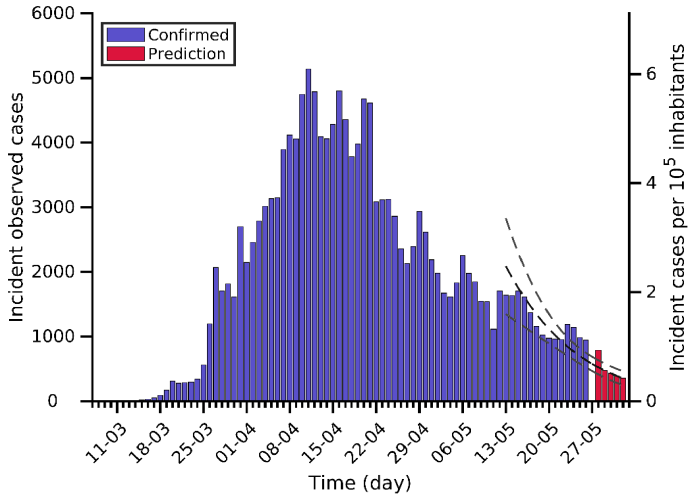
Turkey 27-05-2020. Population: 84.3M. Current cumulated incidence: 188/10^5

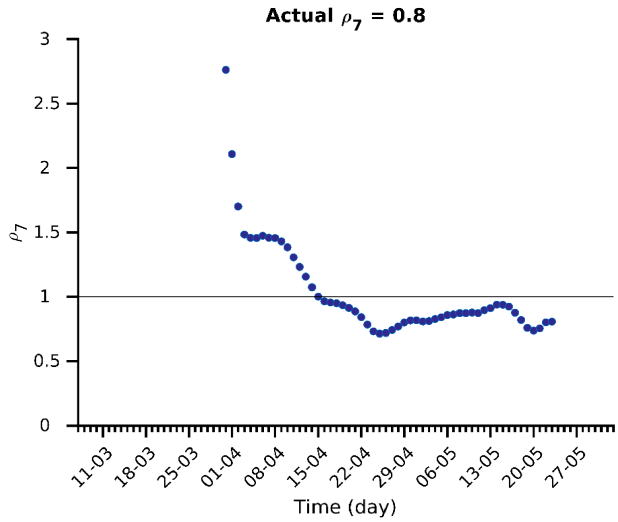


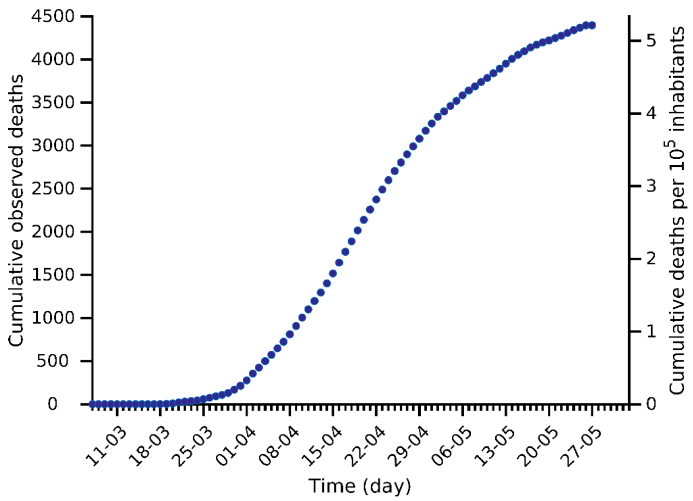


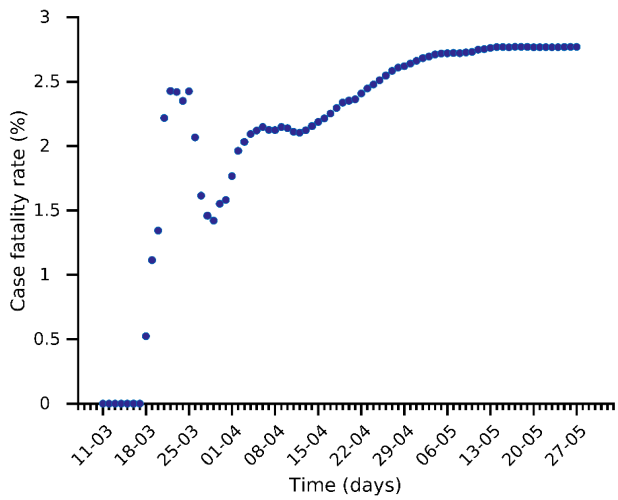




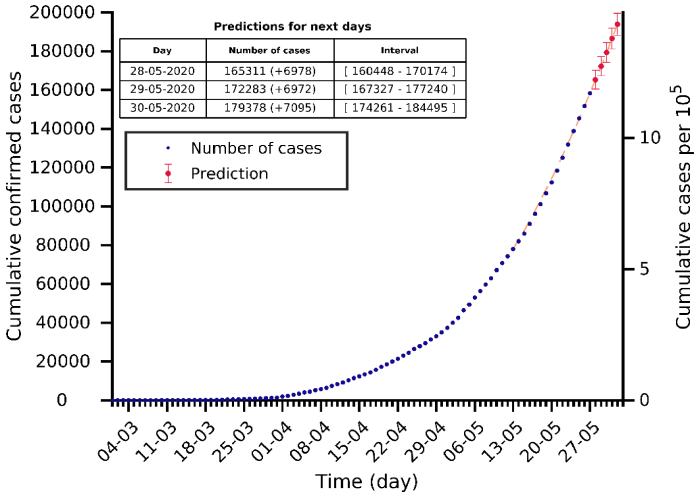


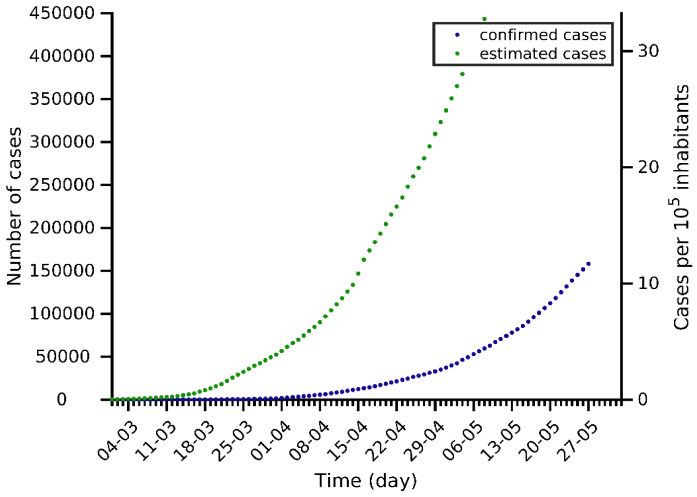


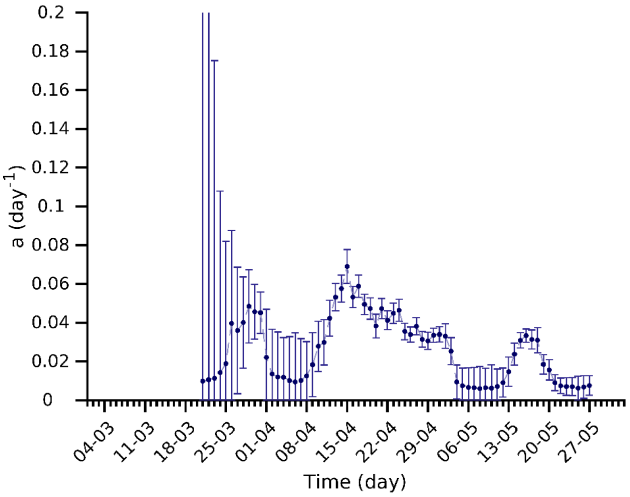


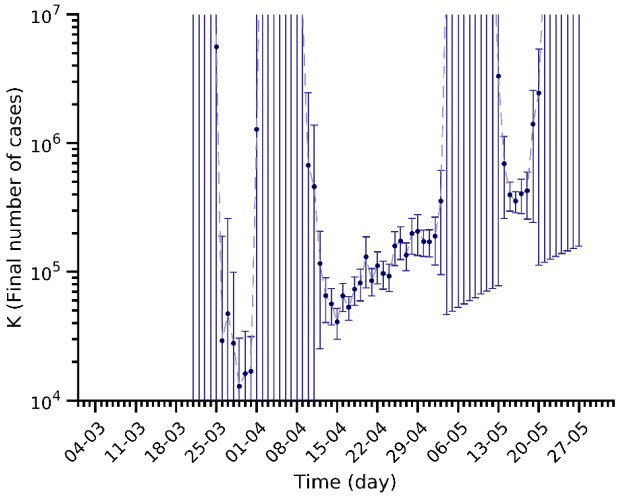


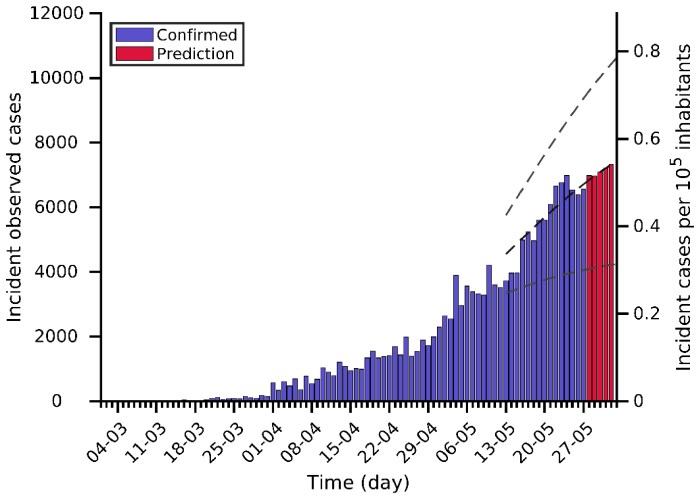
India 27-05-2020. Population: 1353.0M. Current cumulated incidence: 12/10^5

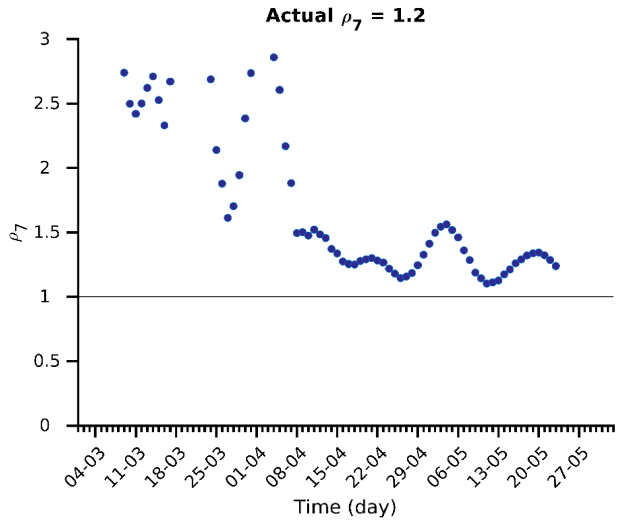


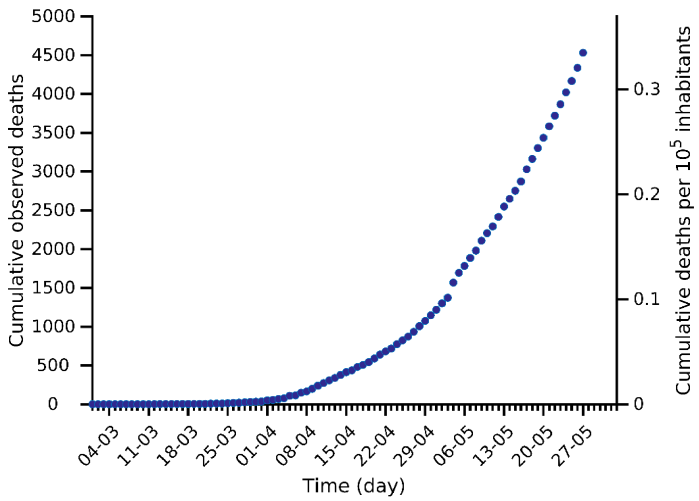


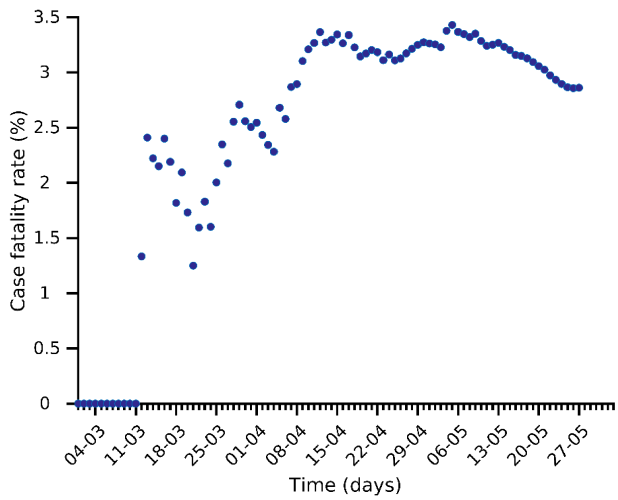




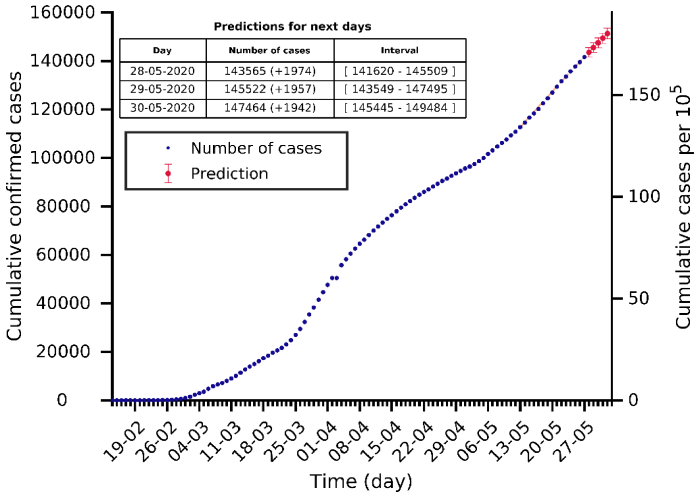


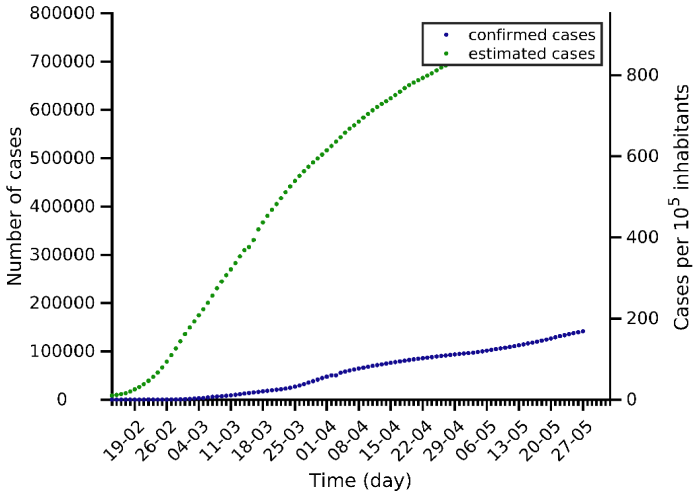


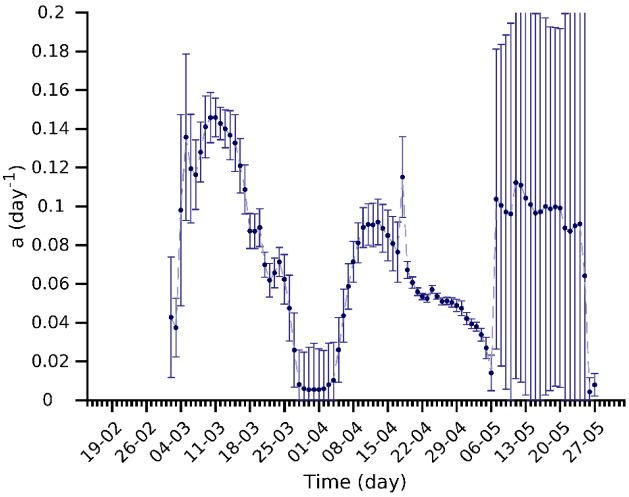


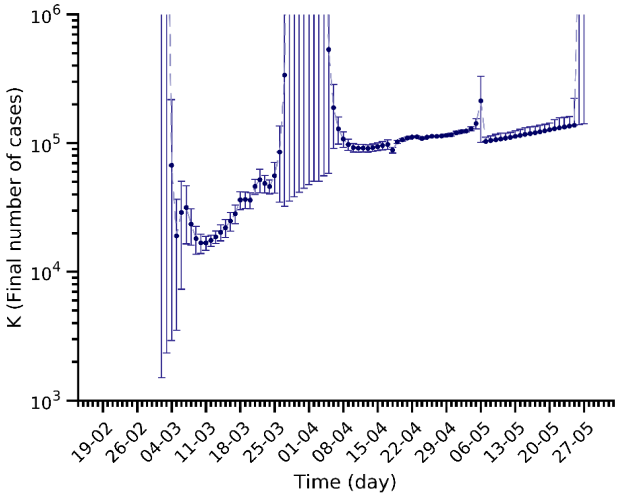


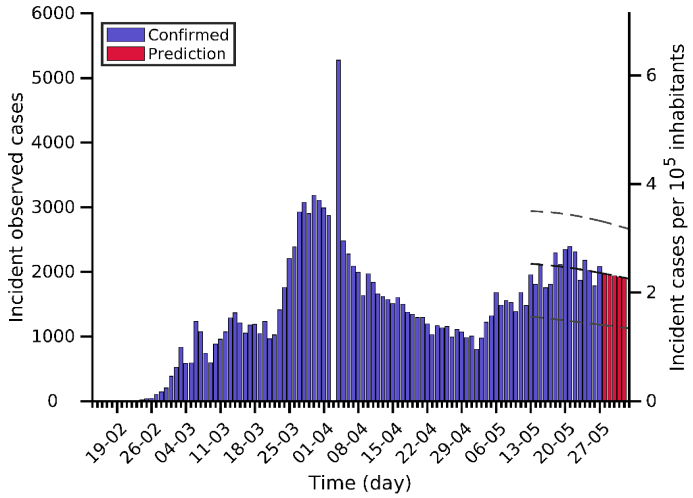
Iran 27-05-2020. Population: 84.0M. Current cumulated incidence: 169/10^5

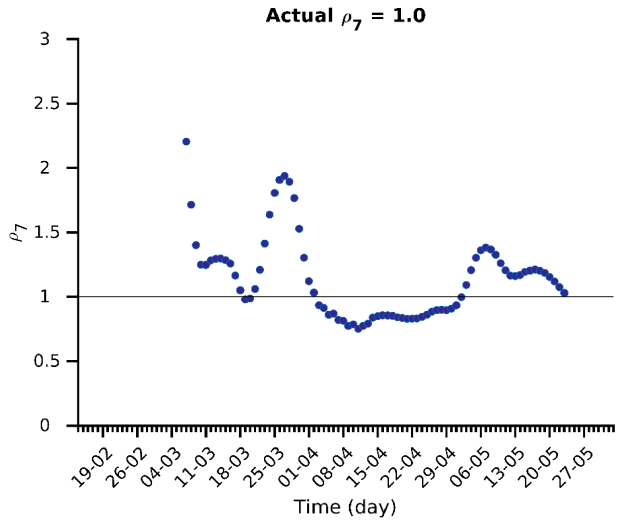


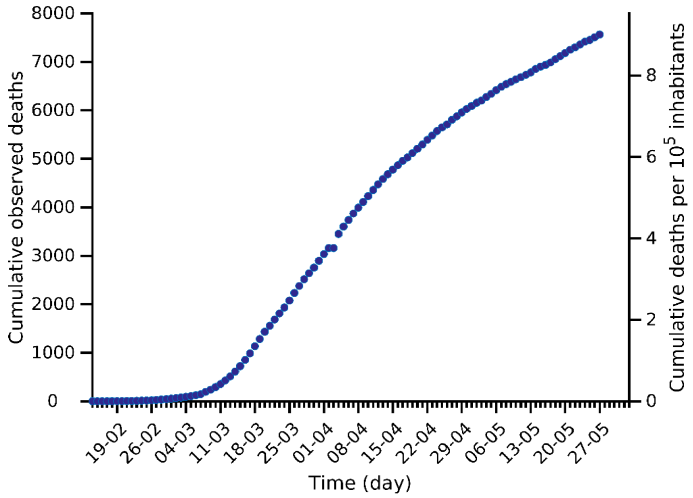


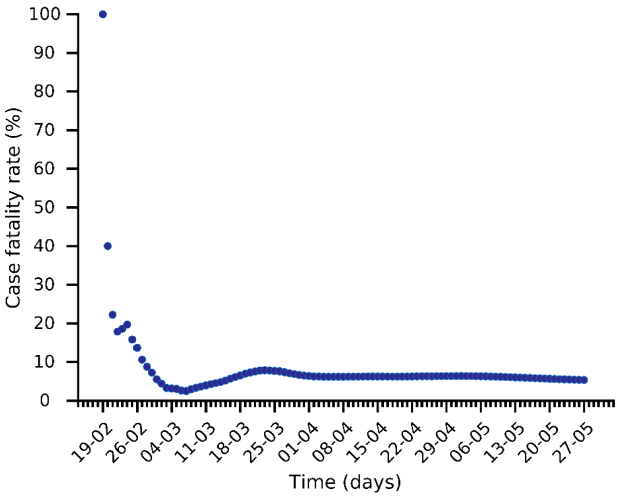




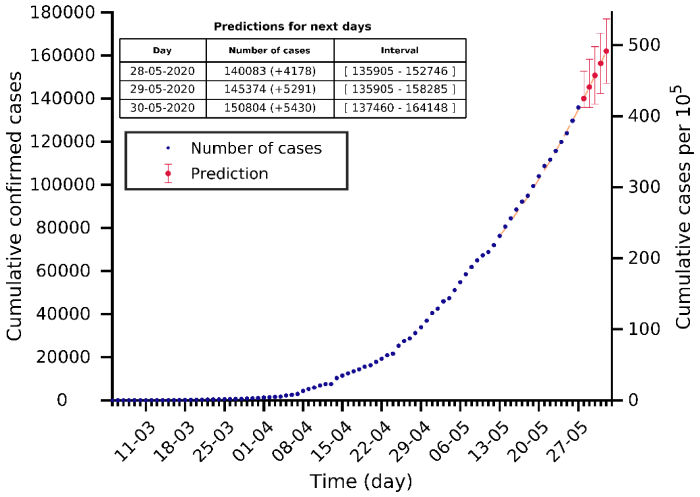


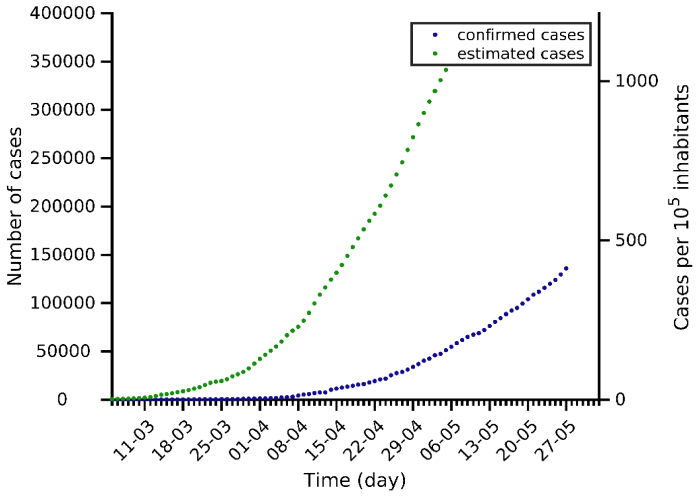


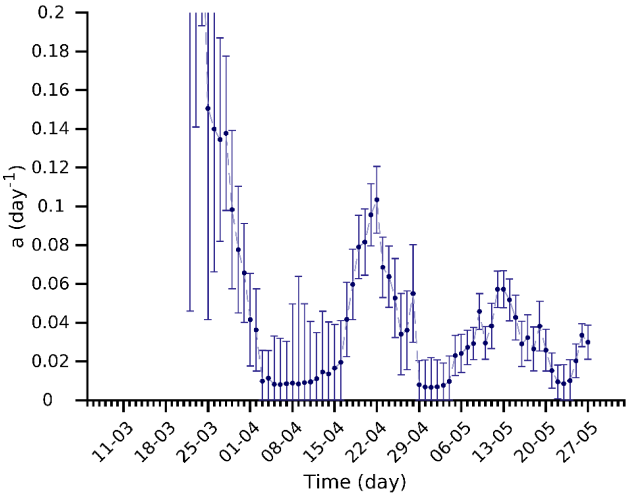


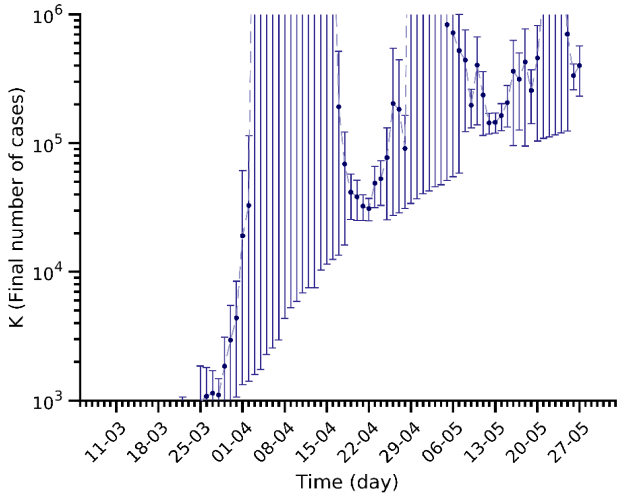


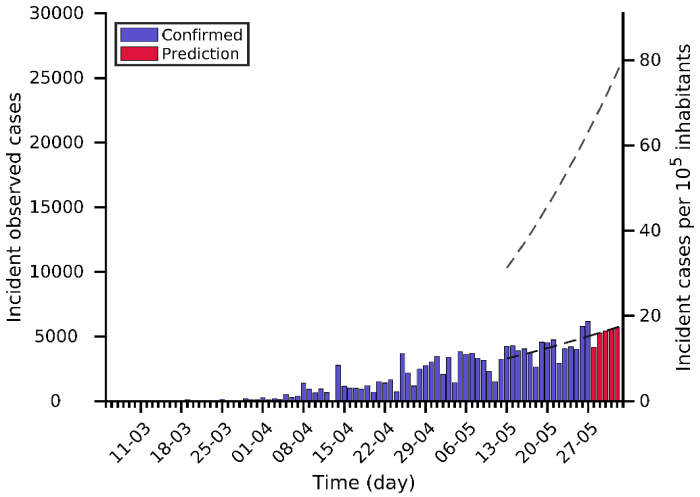
Peru 27-05-2020. Population: 33.0M. Current cumulated incidence: 412/10^5

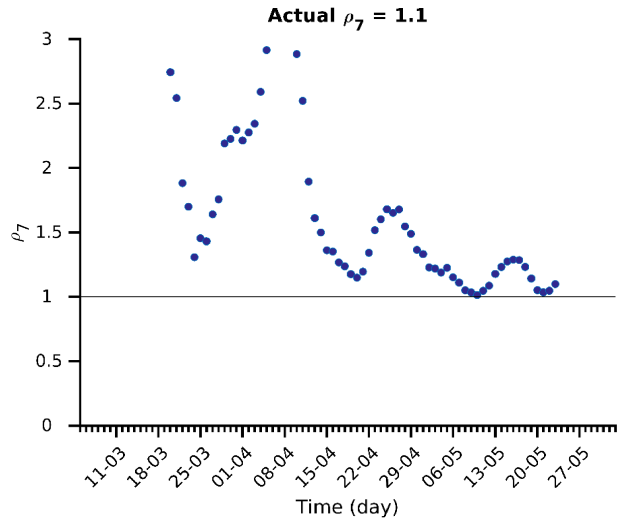


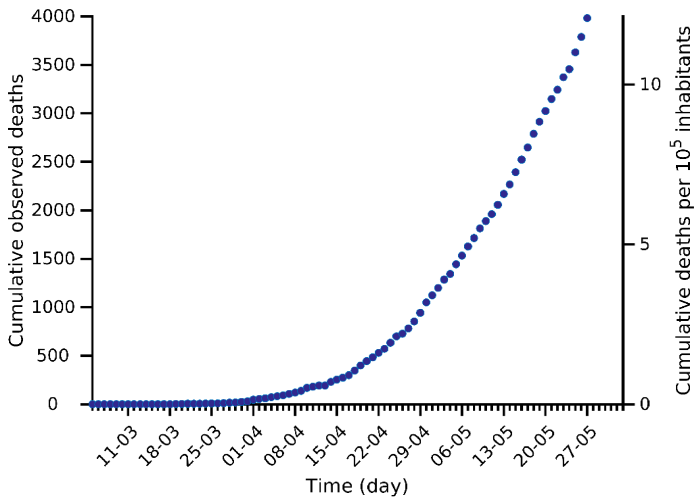


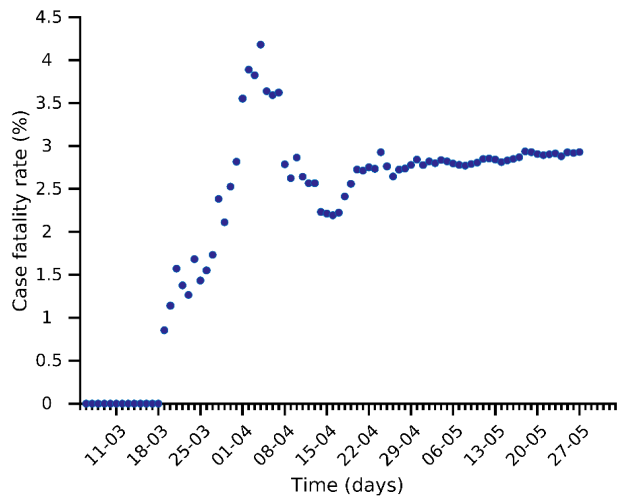




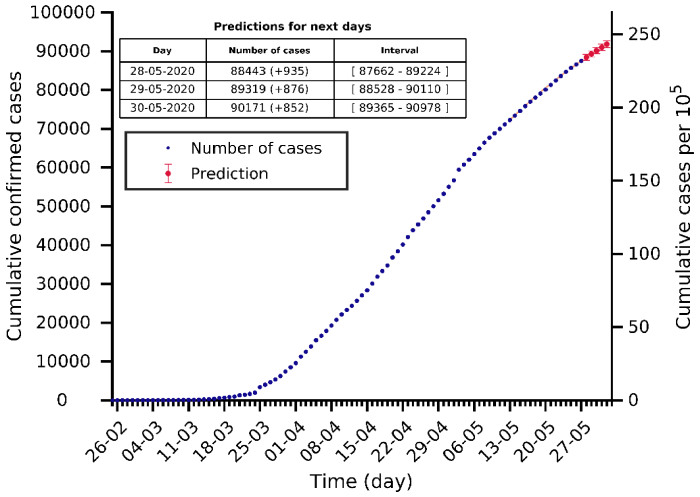


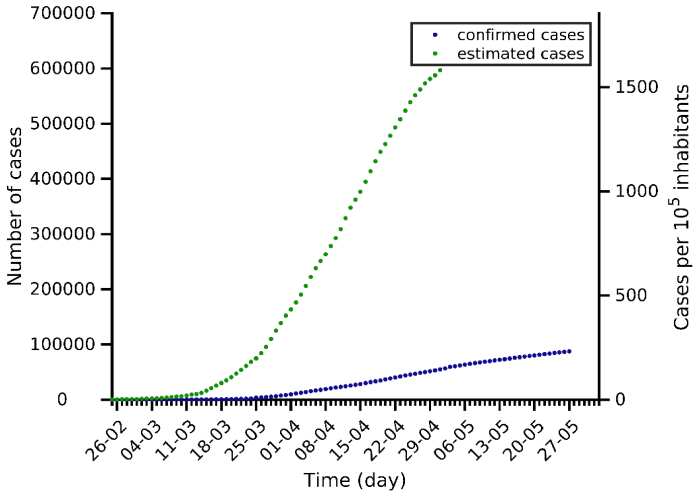


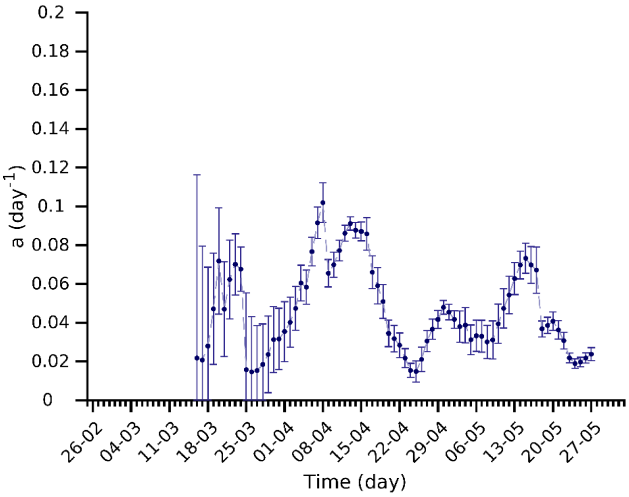


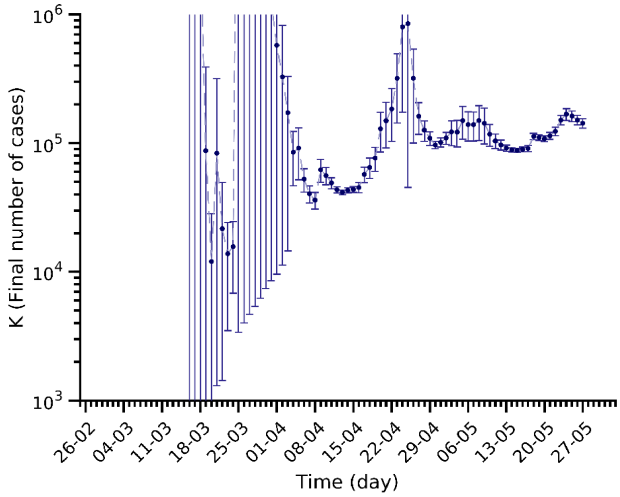


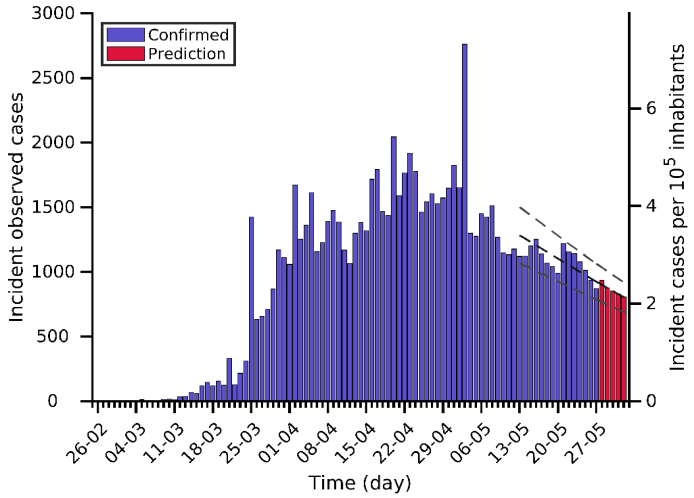
Canada 27-05-2020. Population: 37.7M. Current cumulated incidence: 232/10^5

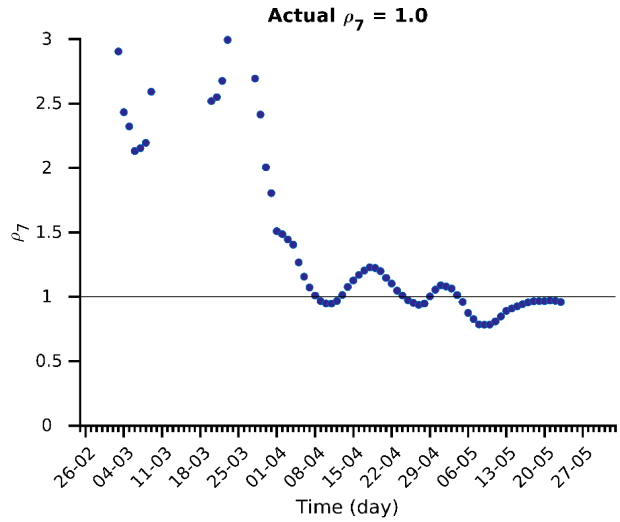


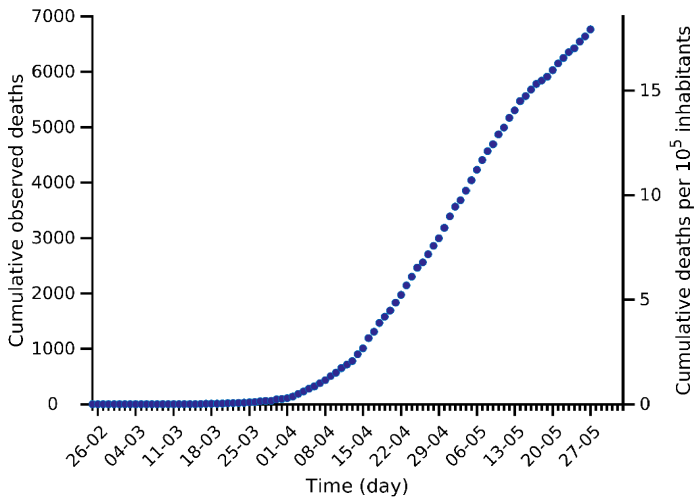


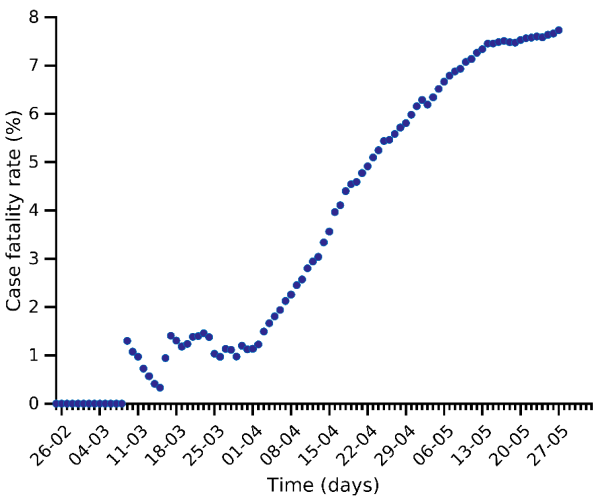




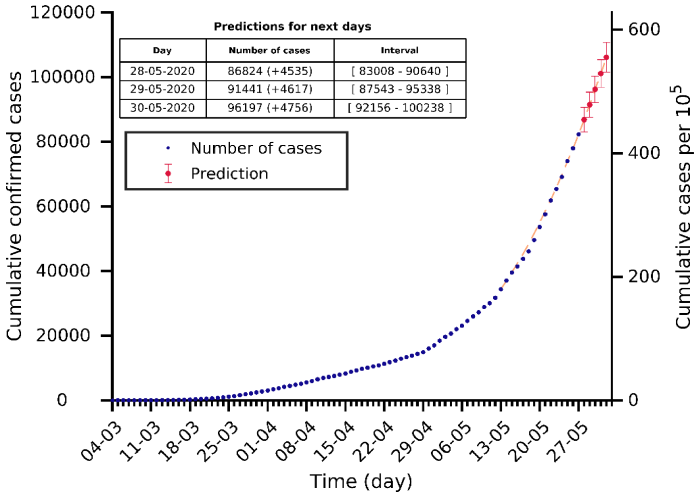


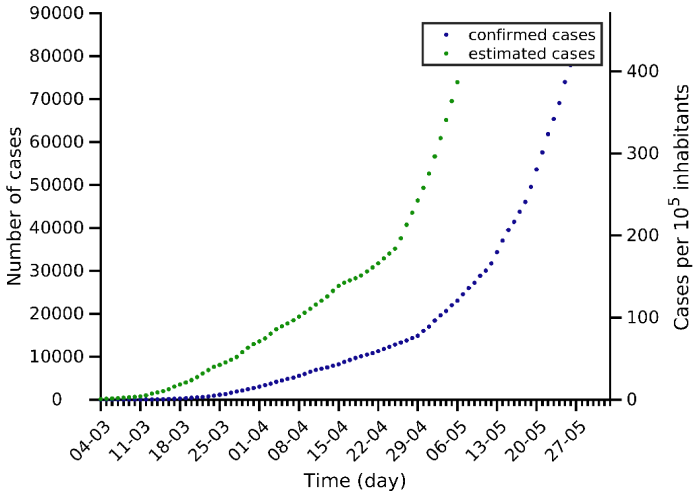


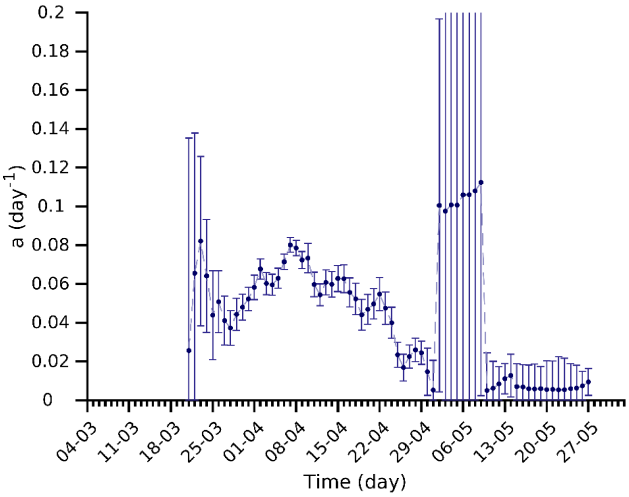


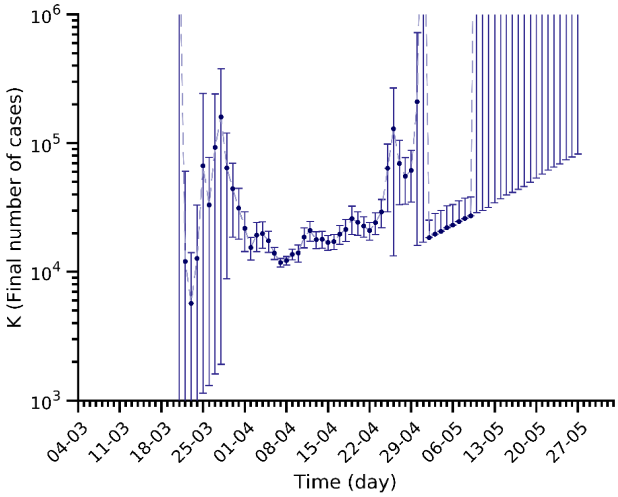


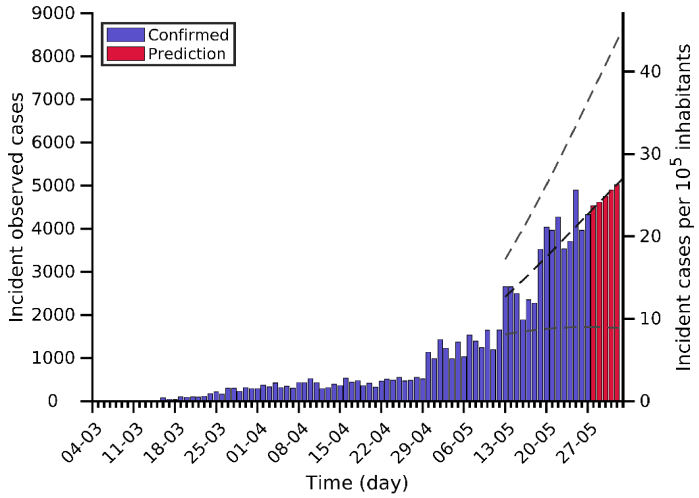
Chile 27-05-2020. Population: 19.1M. Current cumulated incidence: 430/10^5

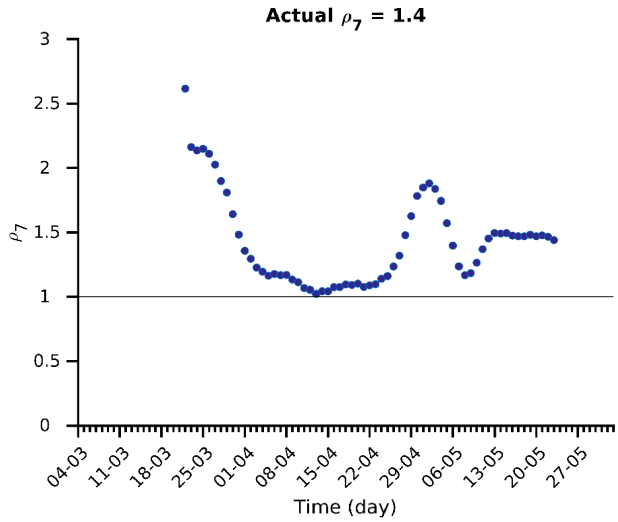


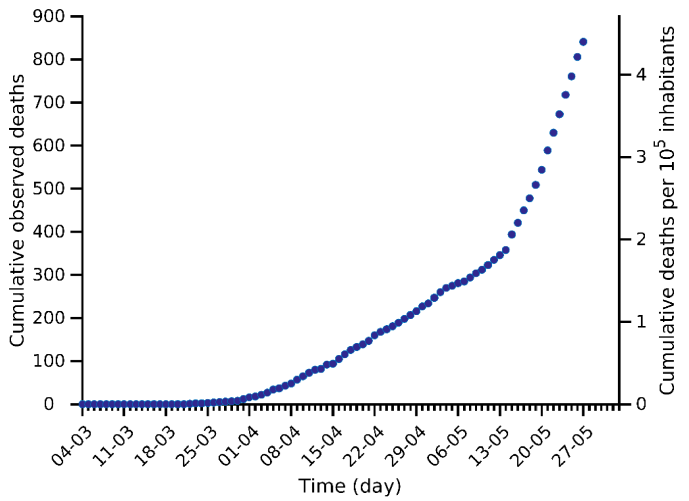


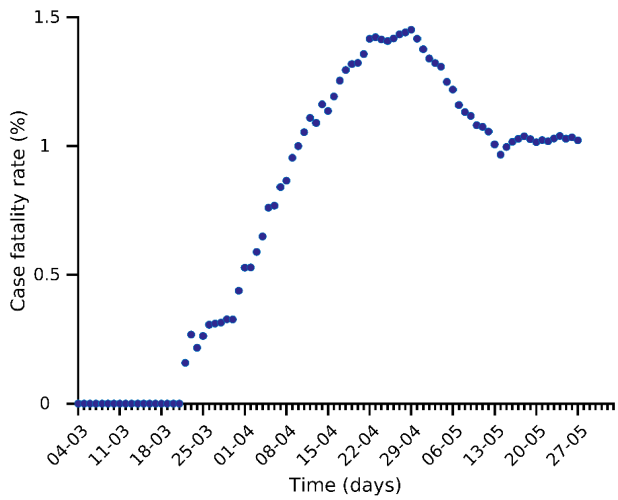




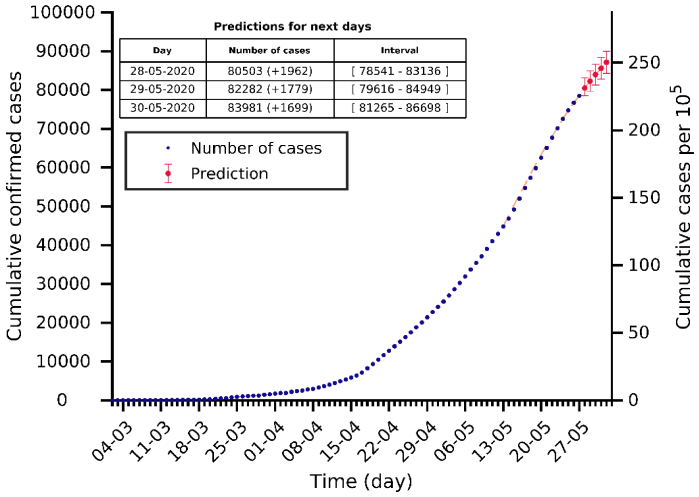


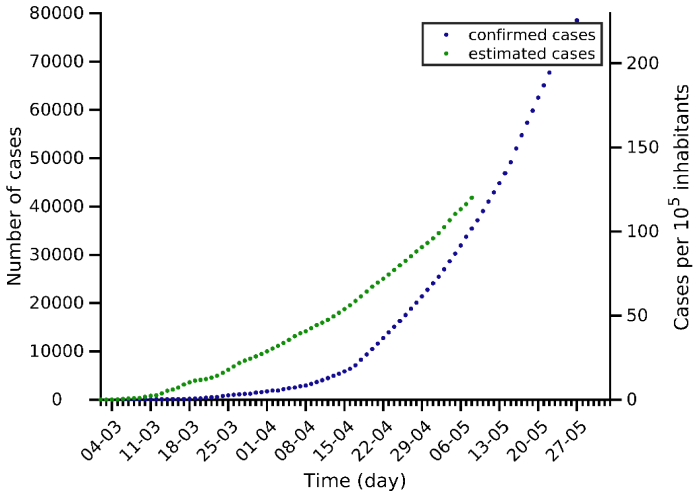


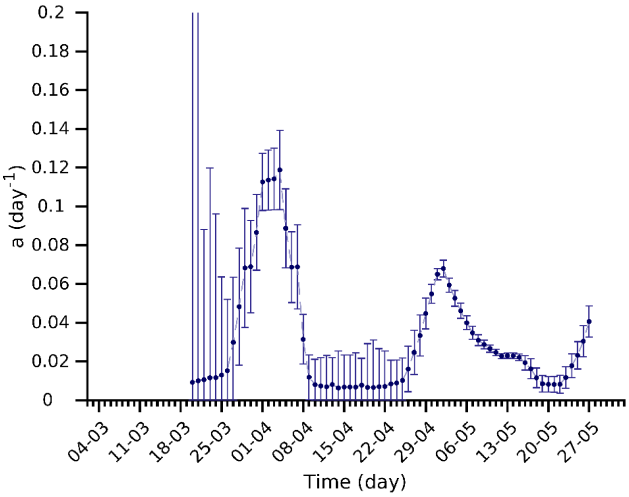


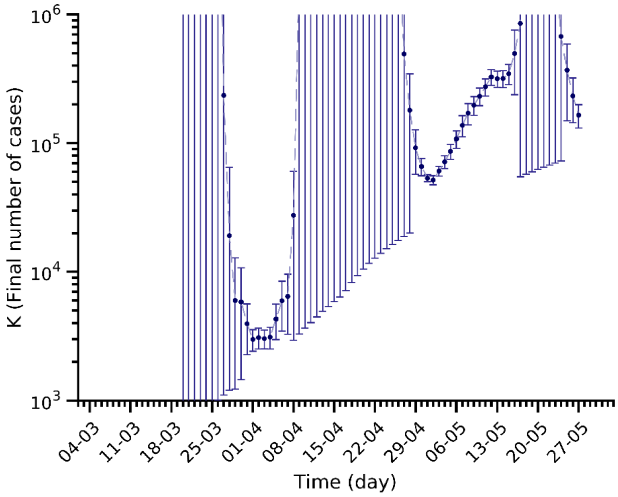


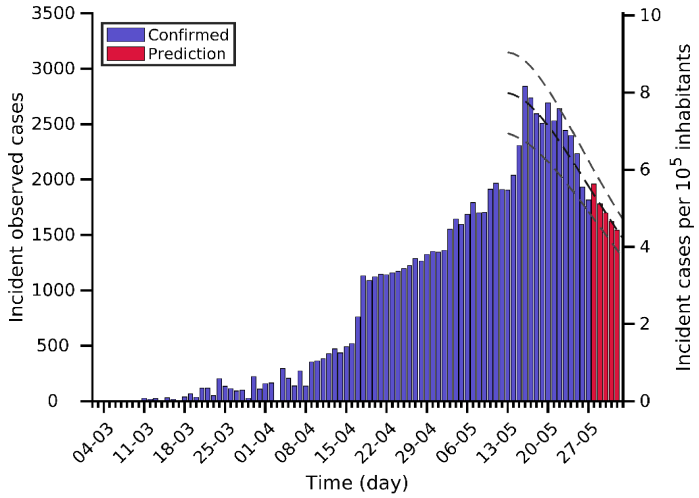
Saudi Arabia 27-05-2020. Population: 34.8M. Current cumulated incidence: 226/10^5

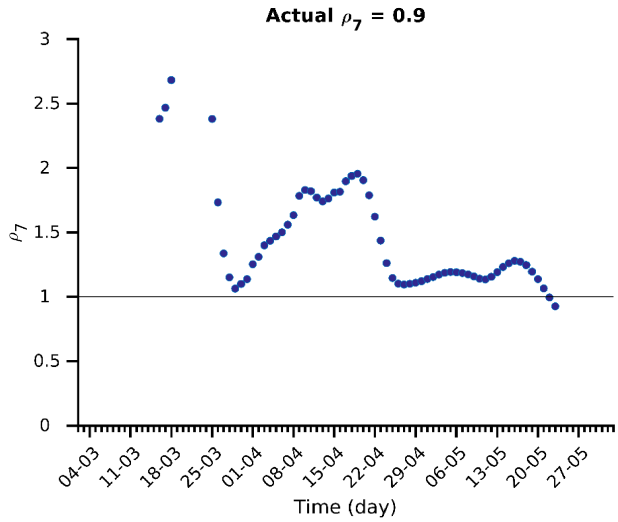


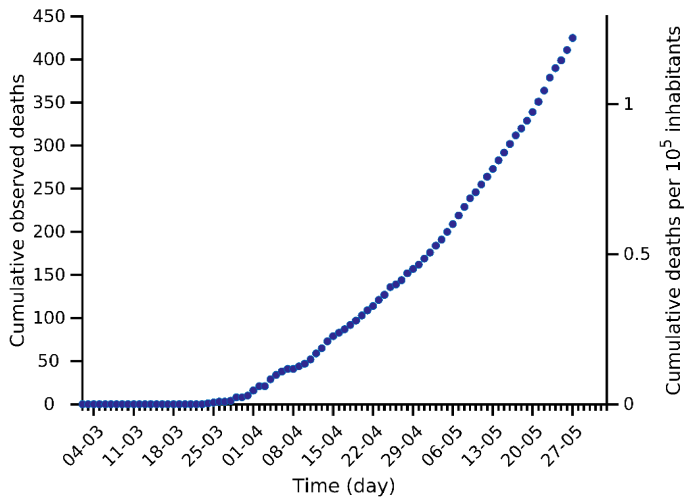


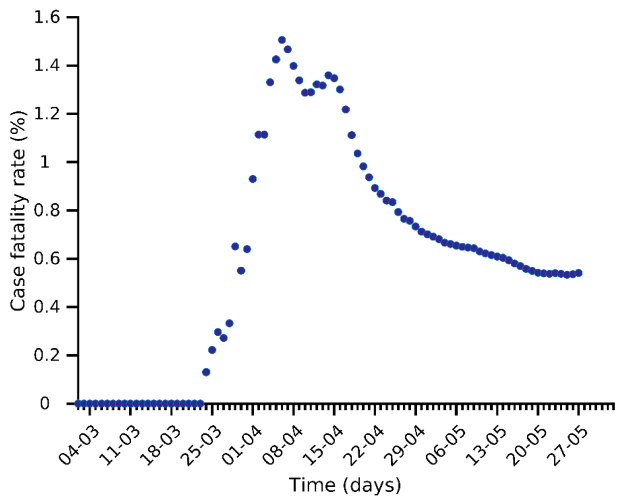




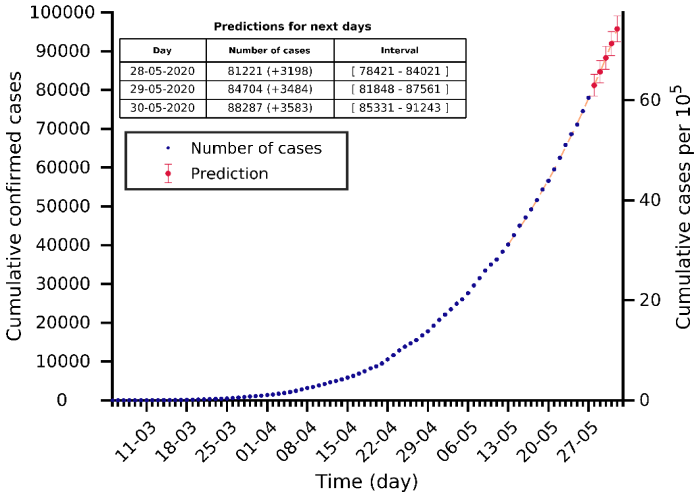


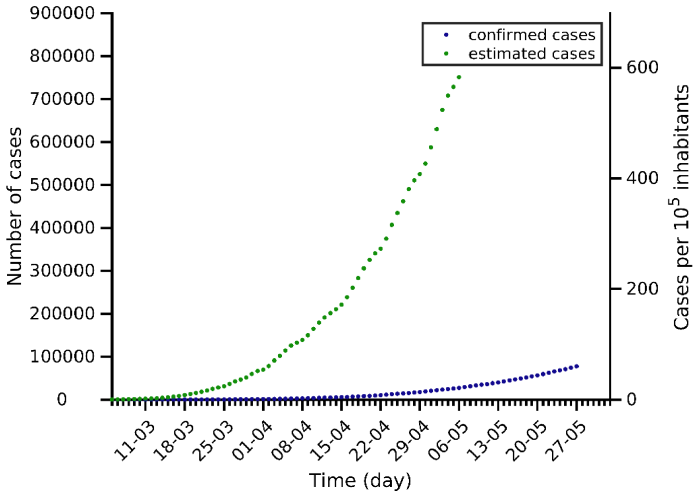


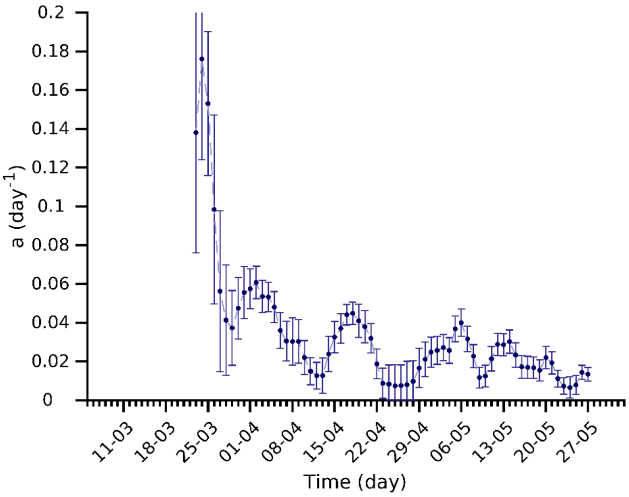


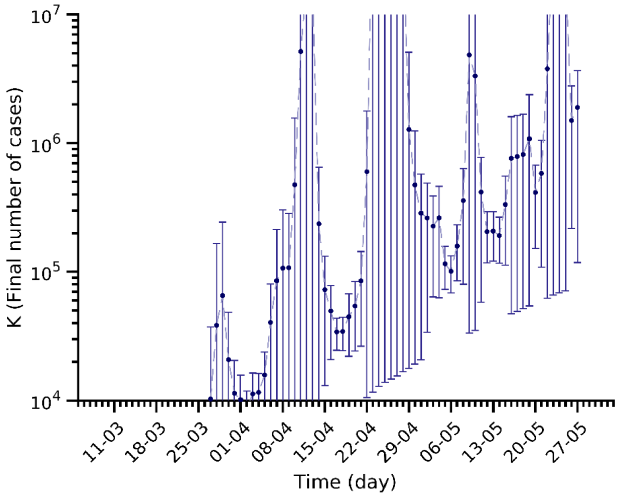


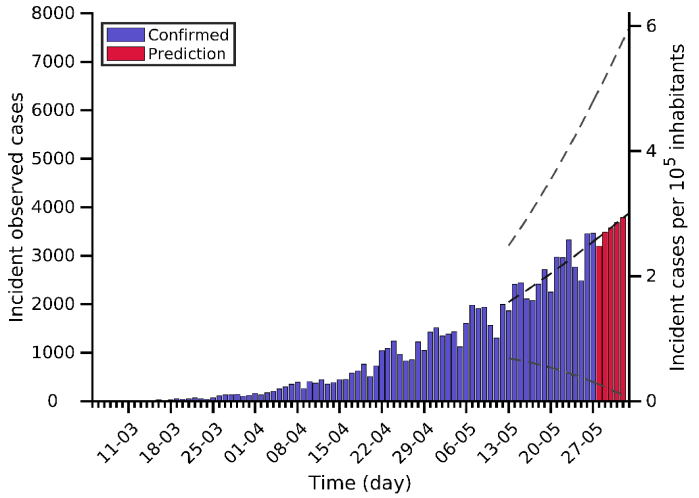
Mexico 27-05-2020. Population: 128.9M. Current cumulated incidence: 61/10^5

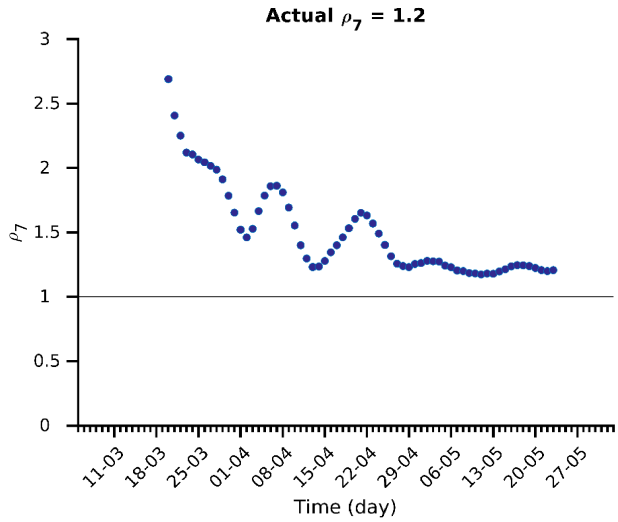


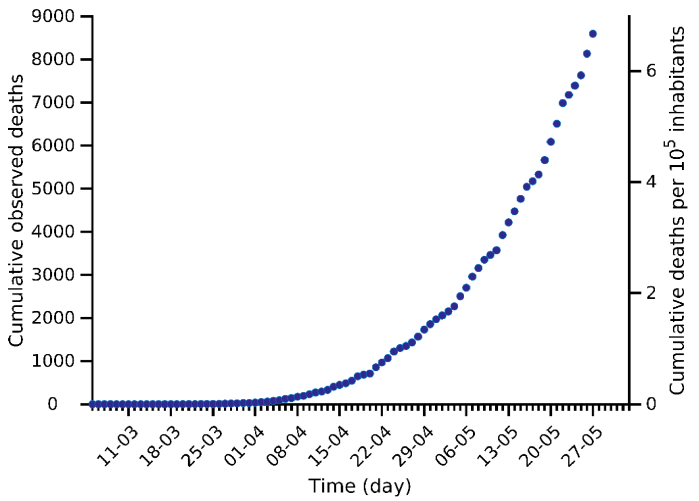


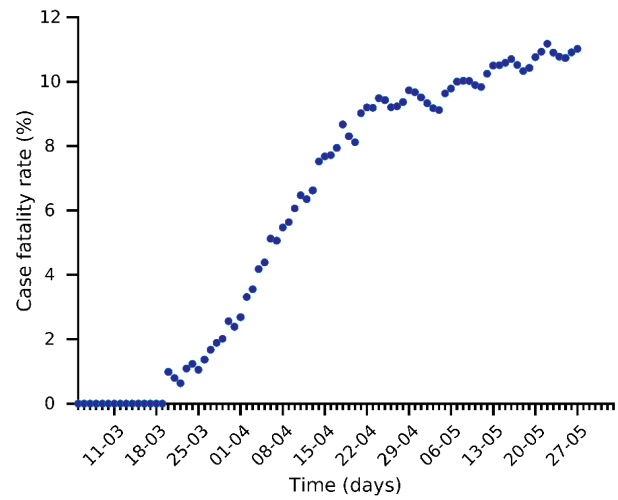




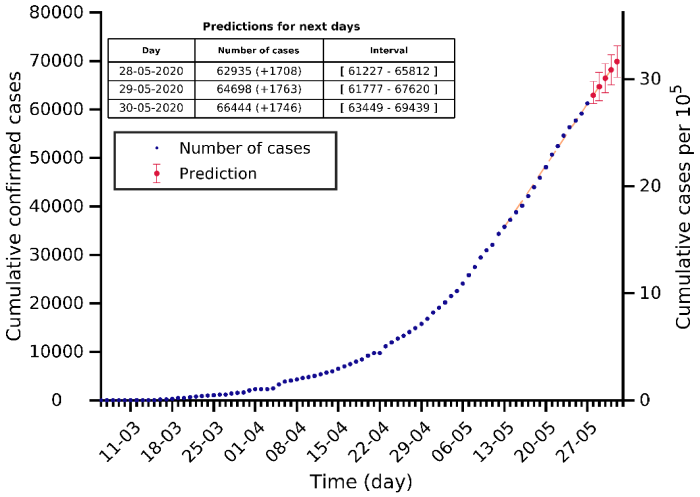


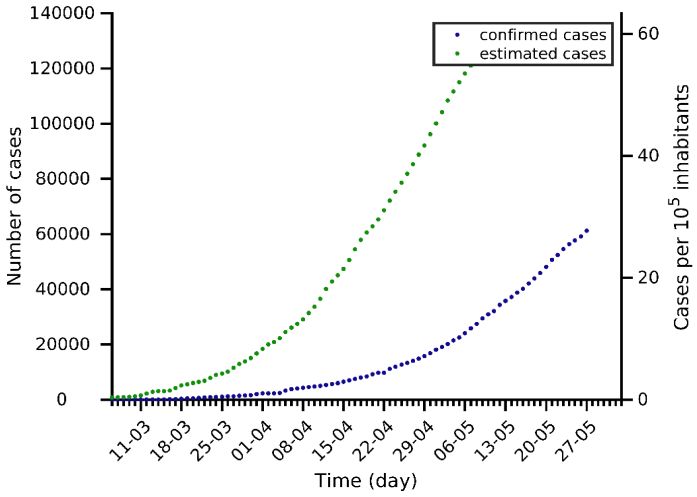


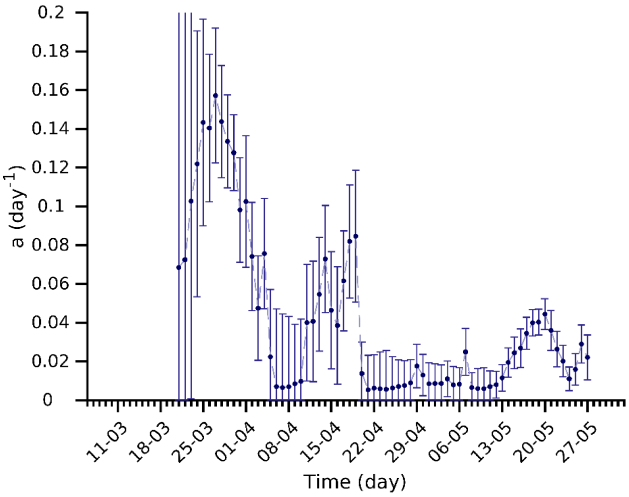


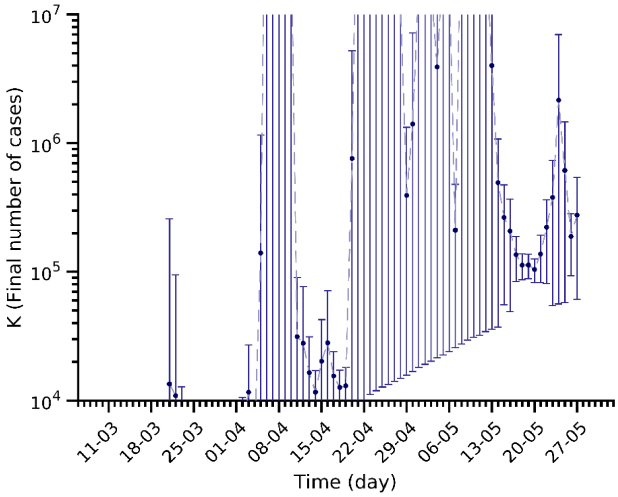


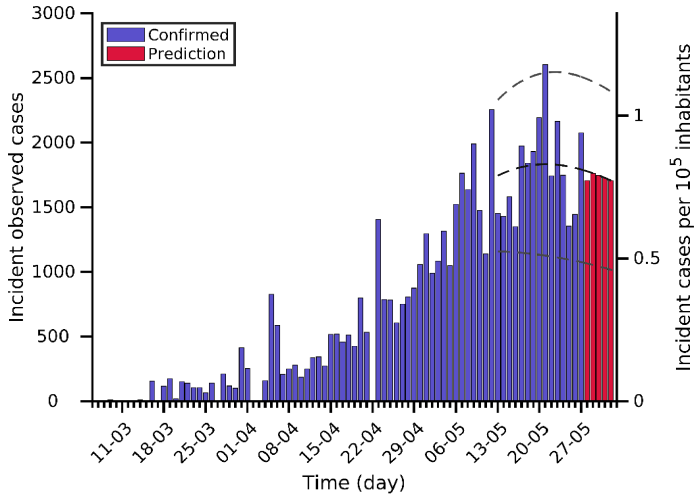
Pakistan 27-05-2020. Population: 220.9M. Current cumulated incidence: 28/10^5

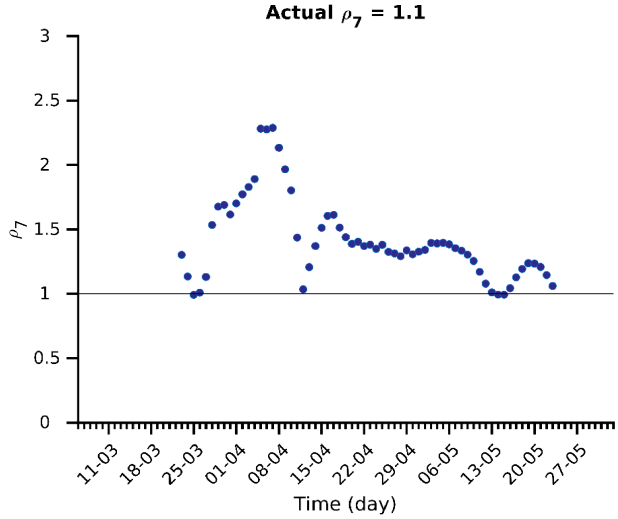


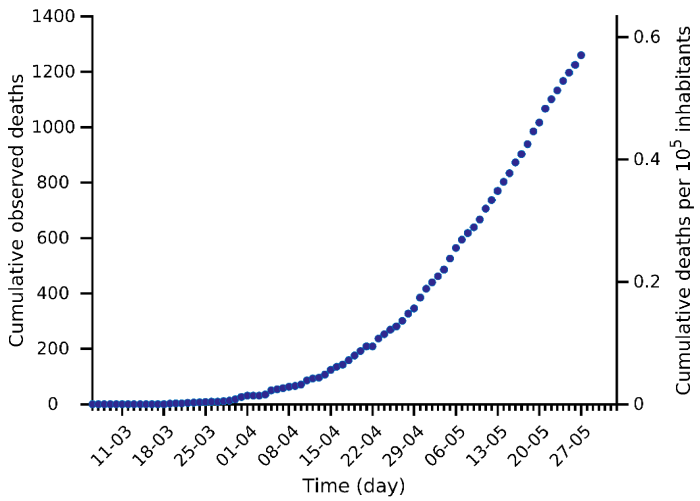


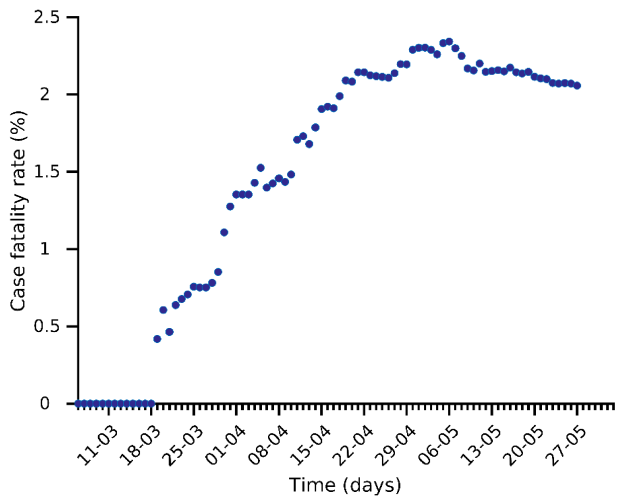




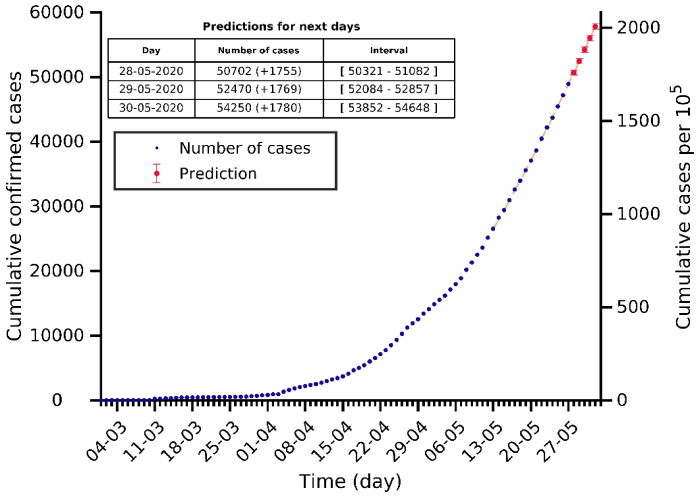


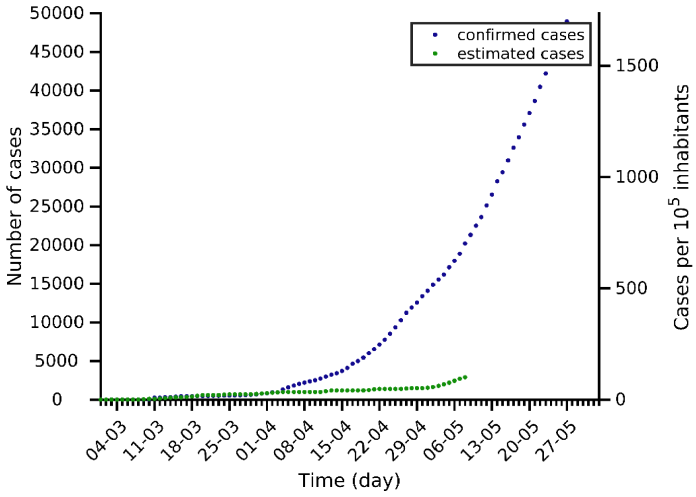


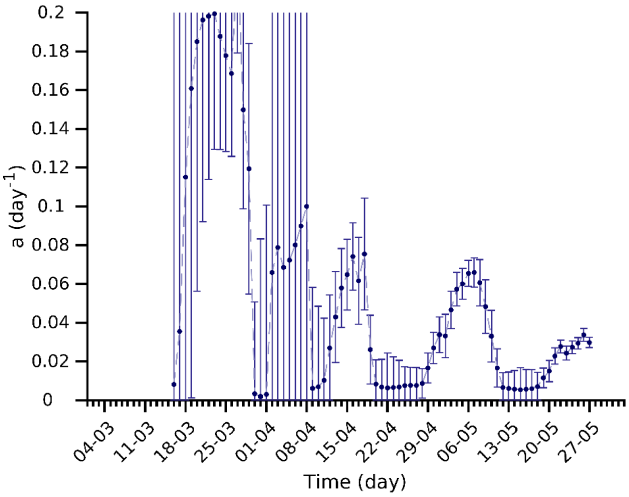


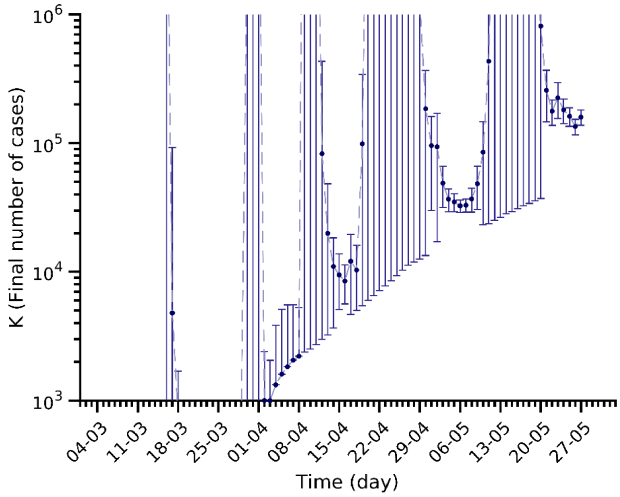


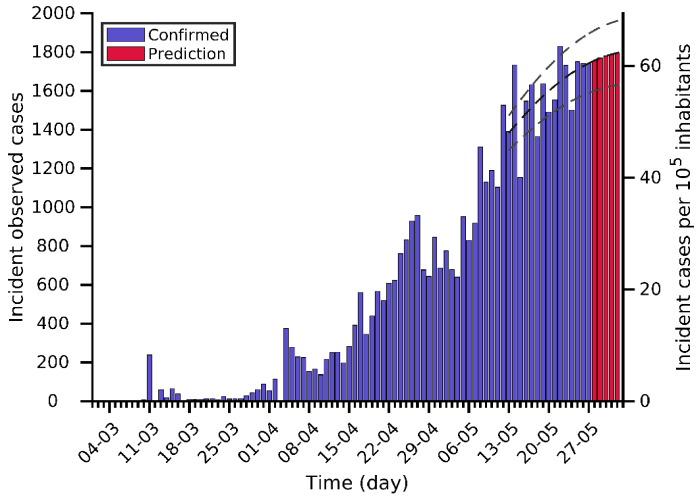
Qatar 27-05-2020. Population: 2.9M. Current cumulated incidence: 1699/10^5

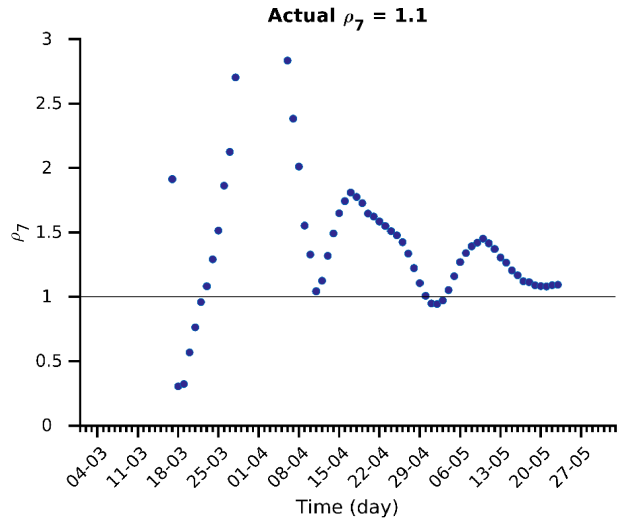


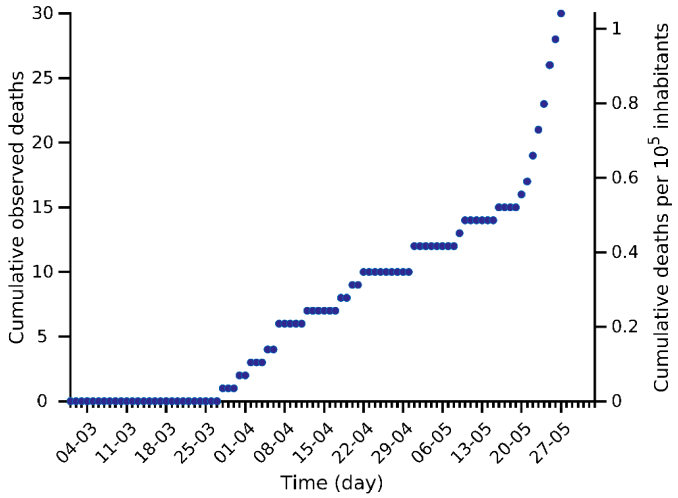


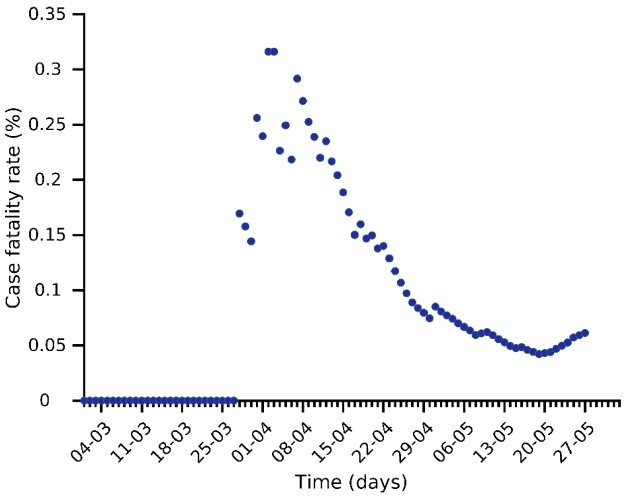




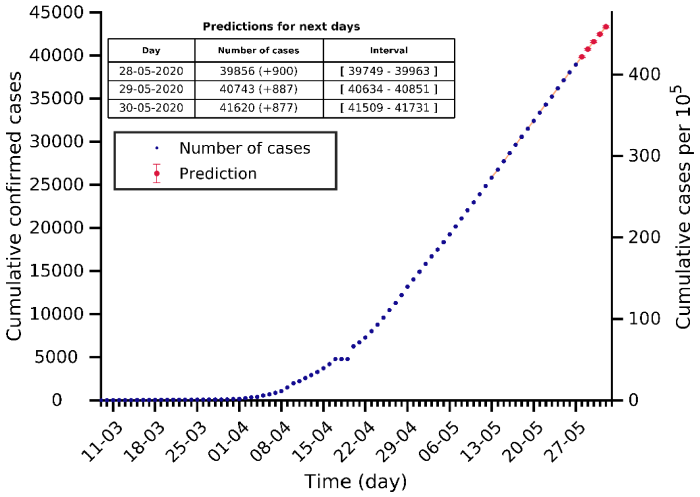


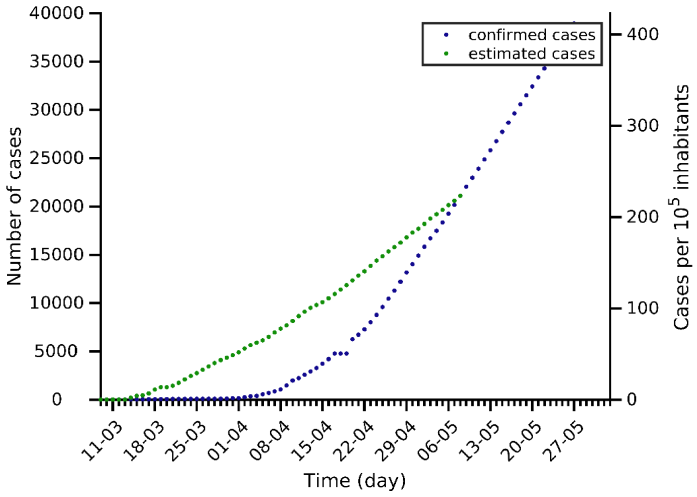


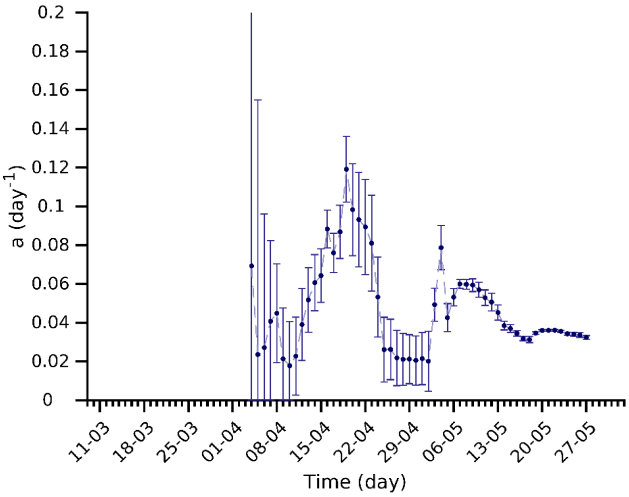


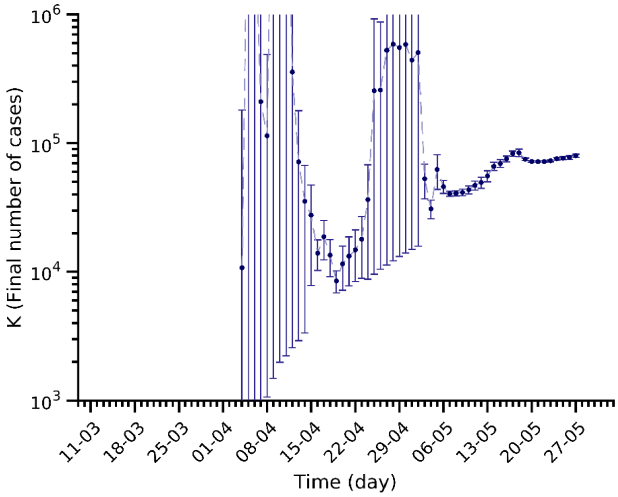


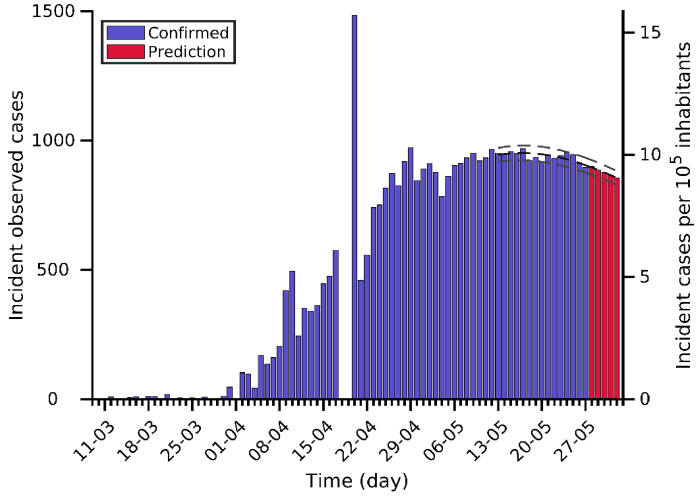
Belarus 27-05-2020. Population: 9.4M. Current cumulated incidence: 412/10⁵

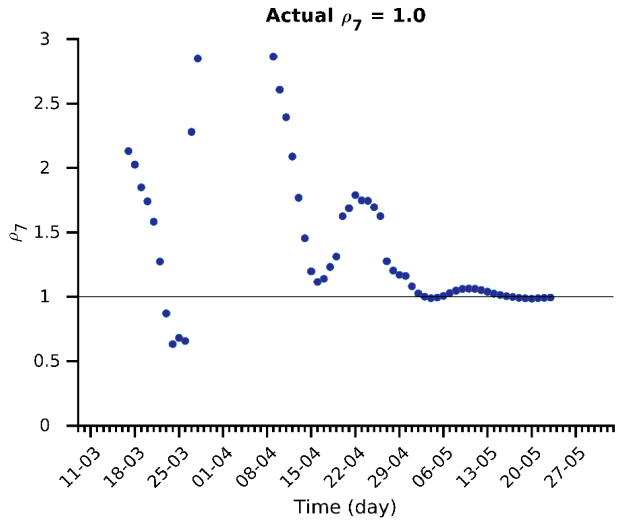


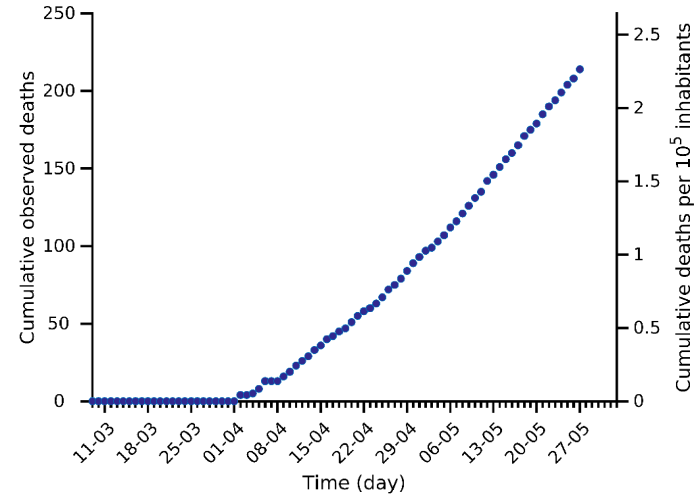


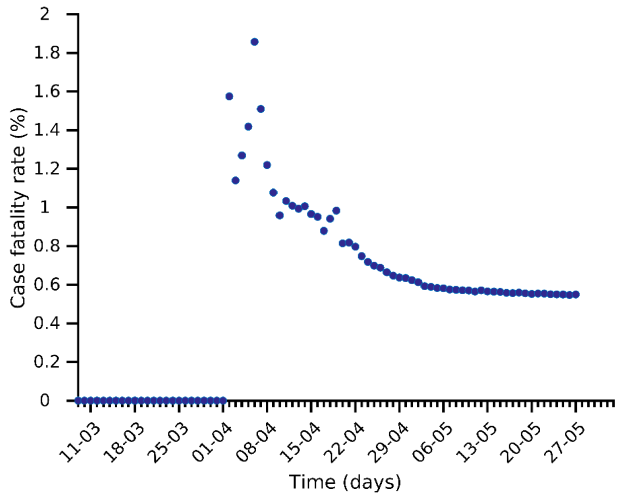




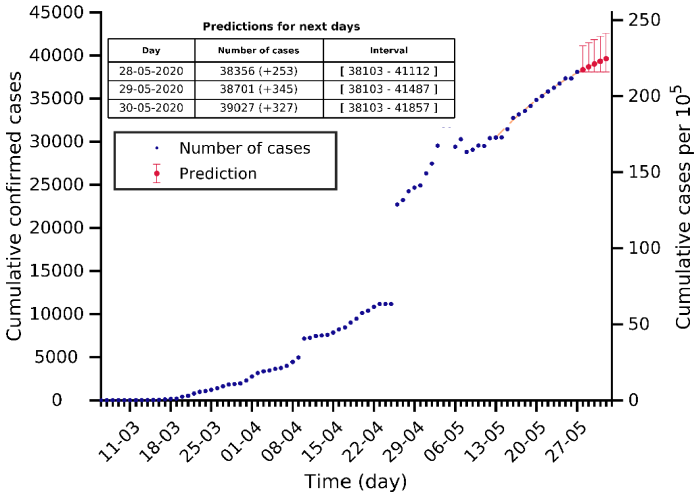


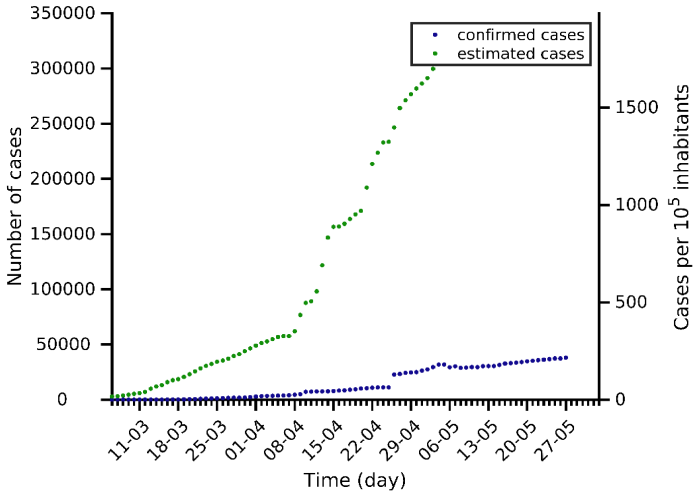


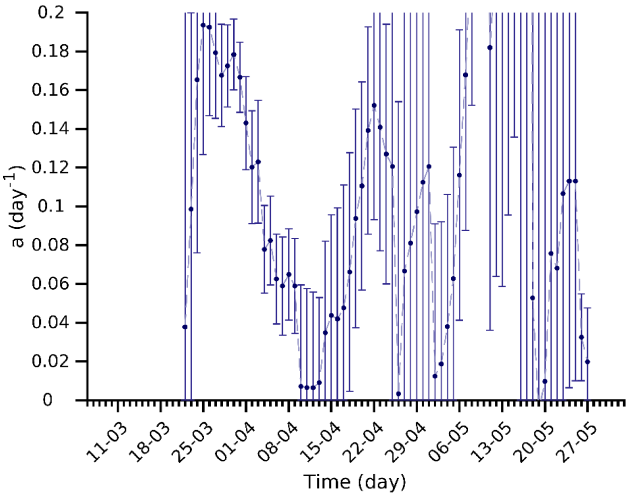


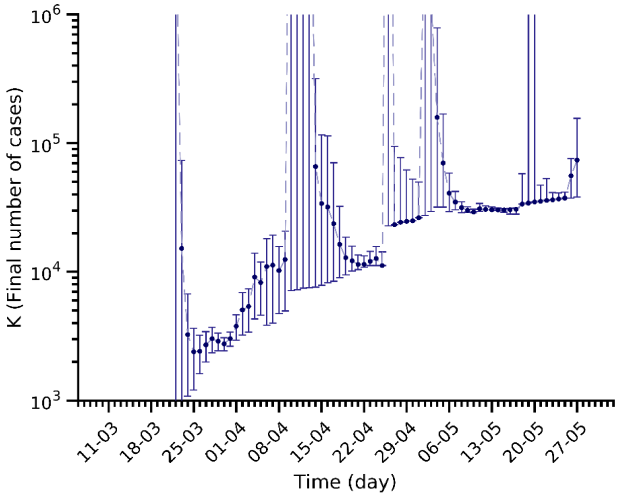


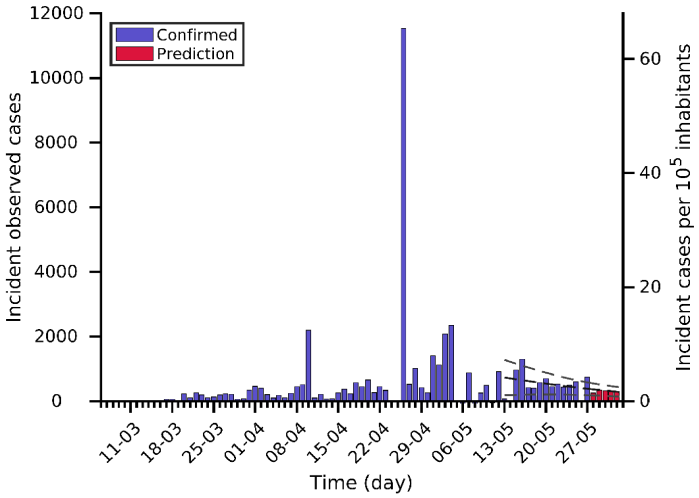
Ecuador 27-05-2020. Population: 17.6M. Current cumulated incidence: 216/10^5

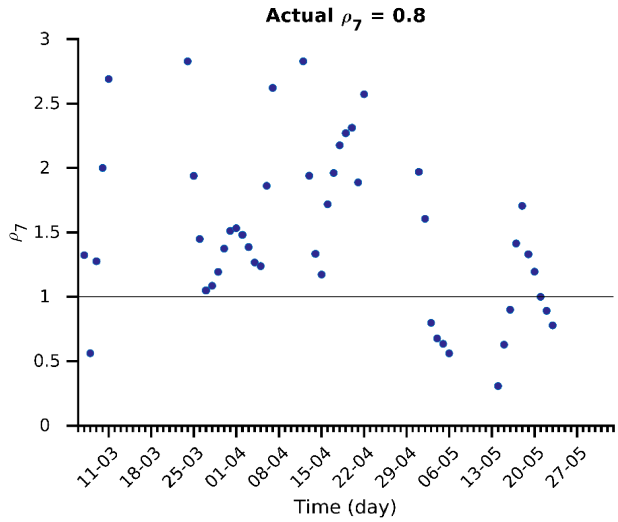


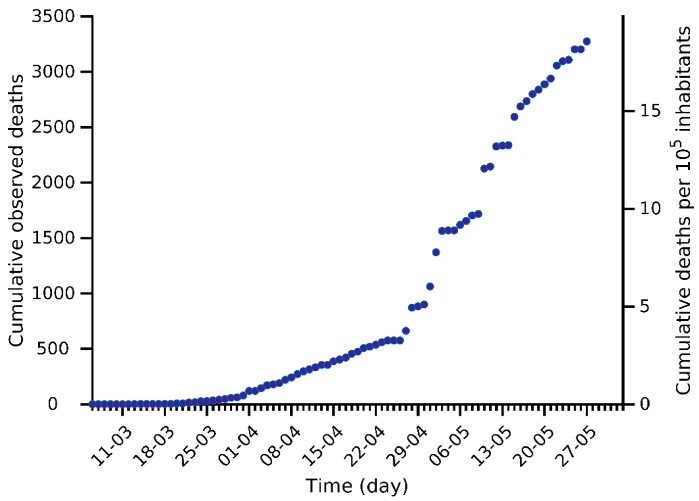


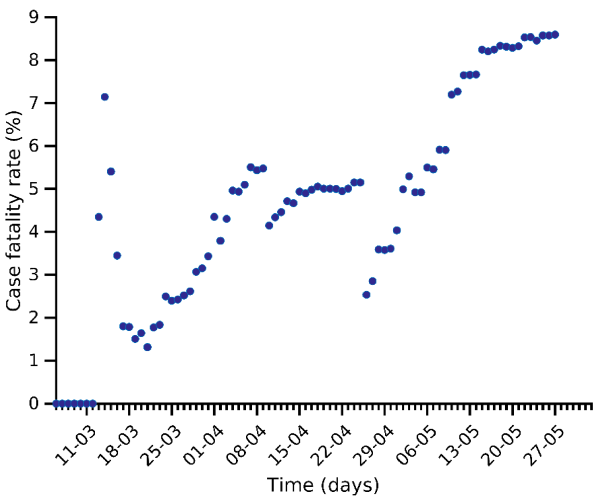




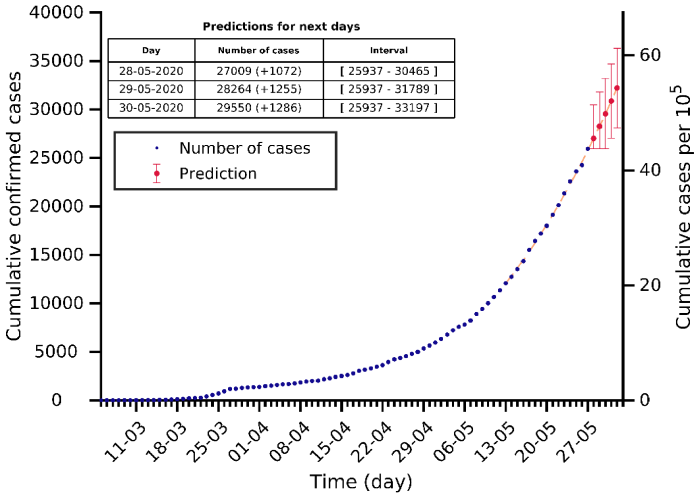


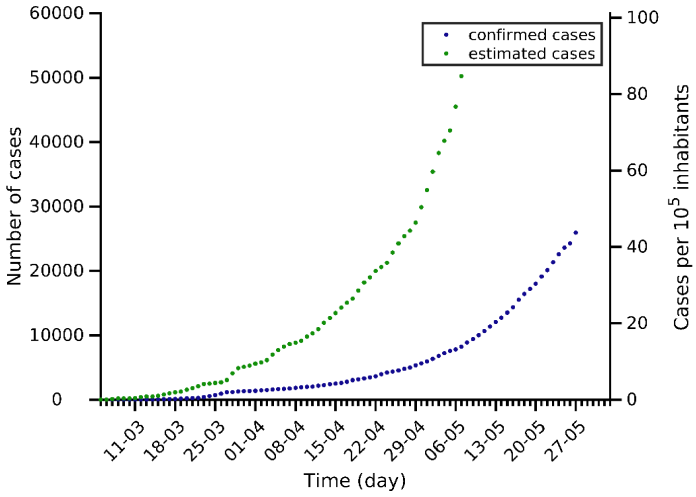


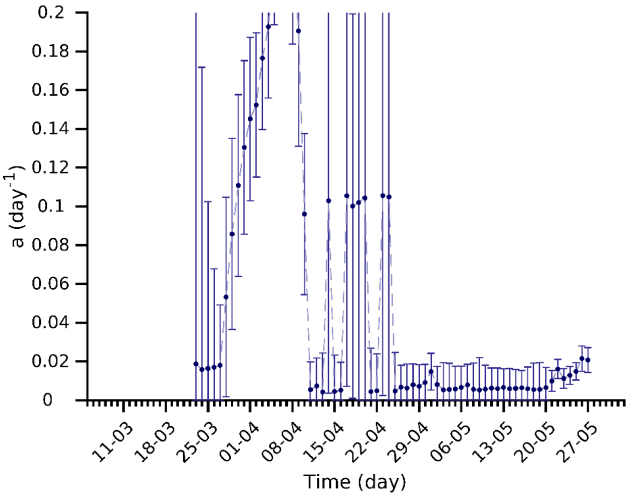


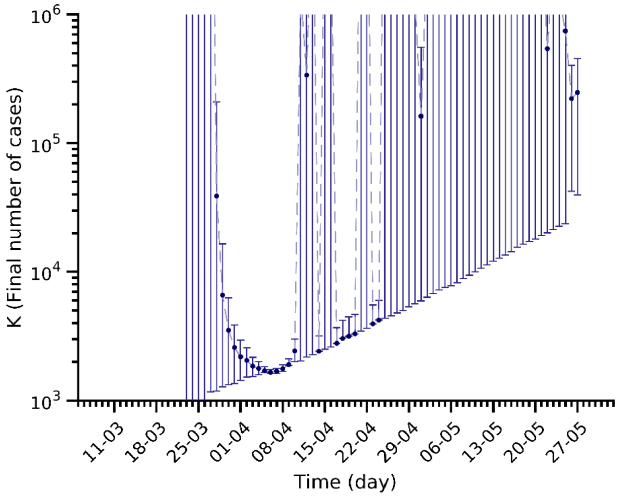


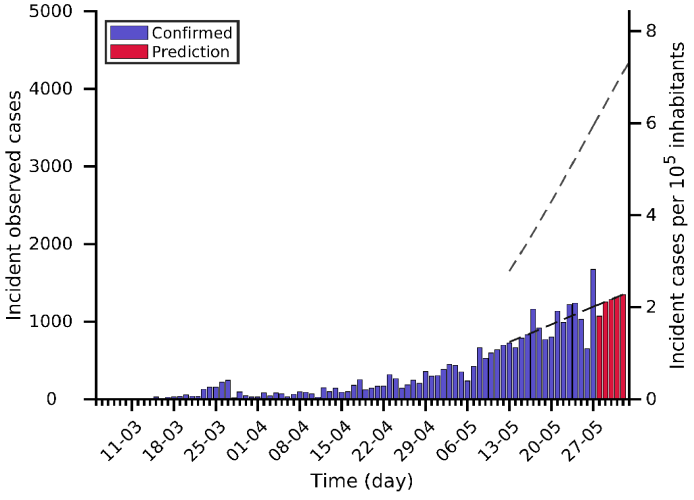
South Africa 27-05-2020. Population: 59.3M. Current cumulated incidence: 44/10^5

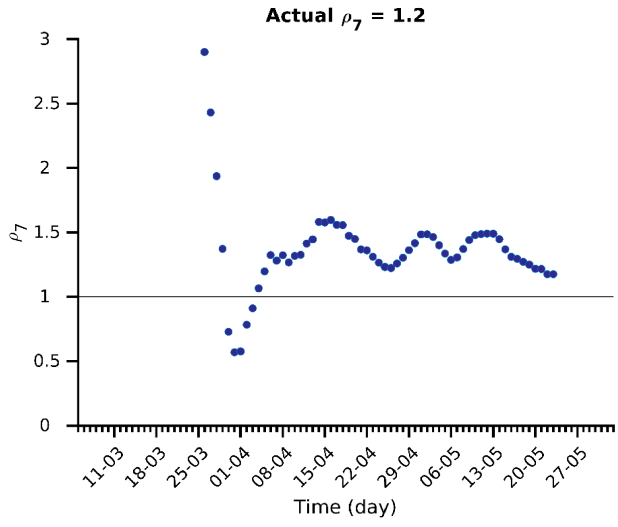


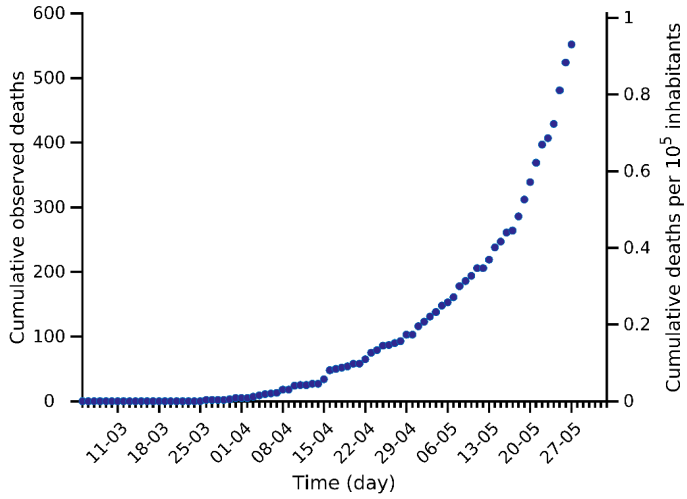


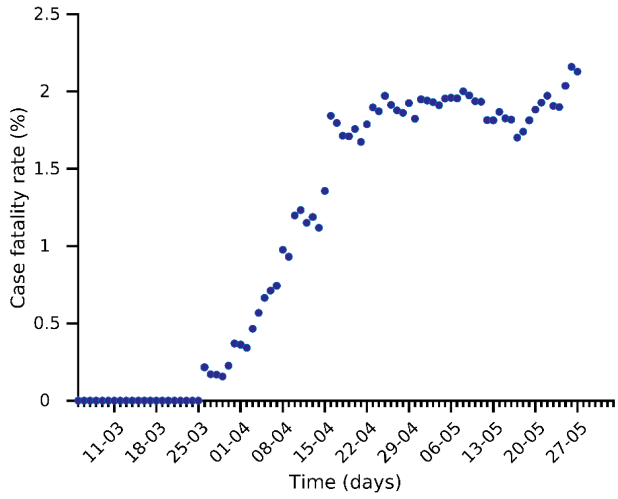




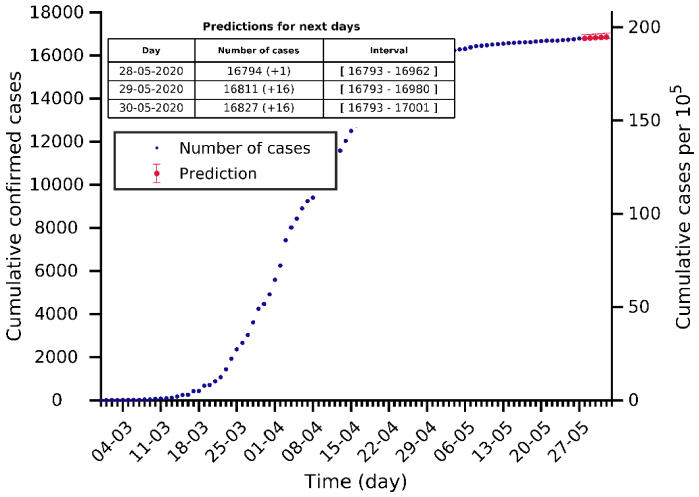


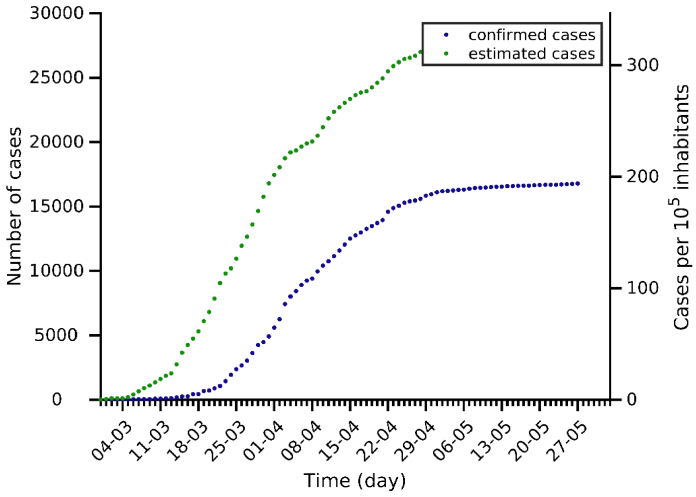


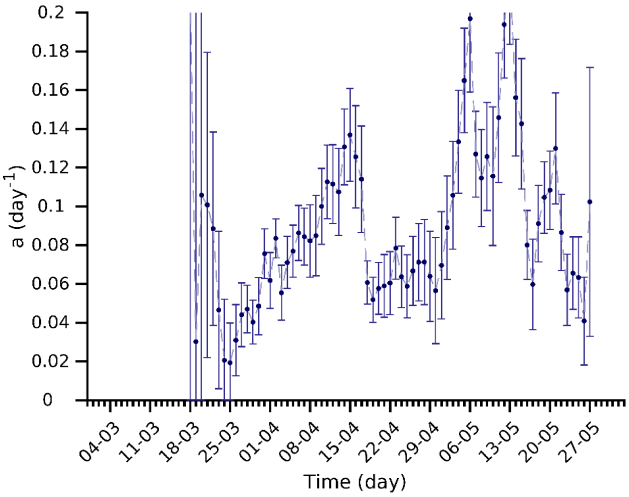


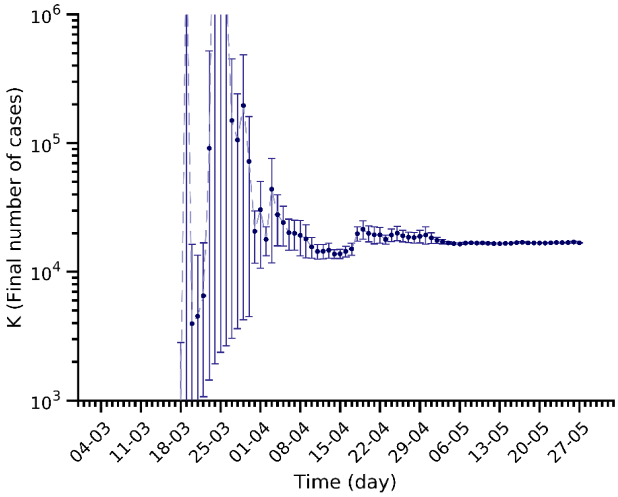


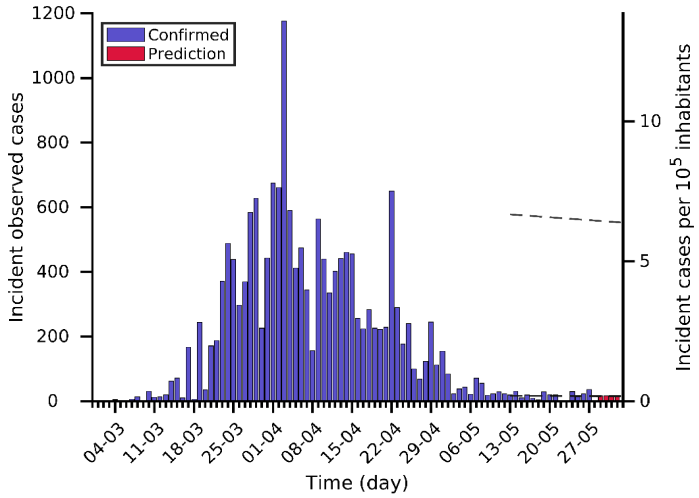
Israel 27-05-2020. Population: 8.7M. Current cumulated incidence: 194/10^5

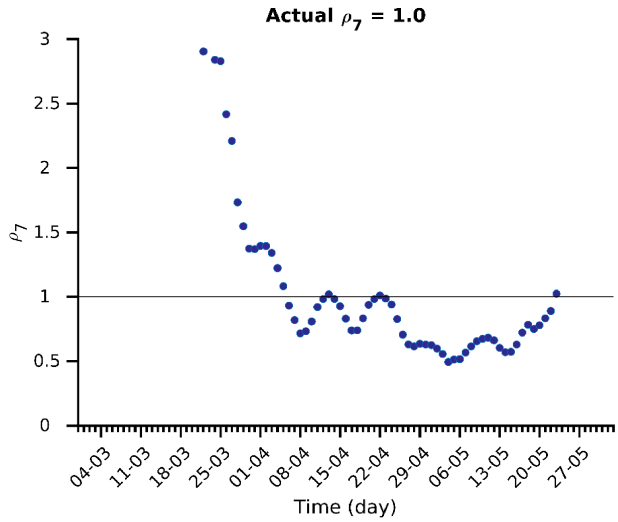


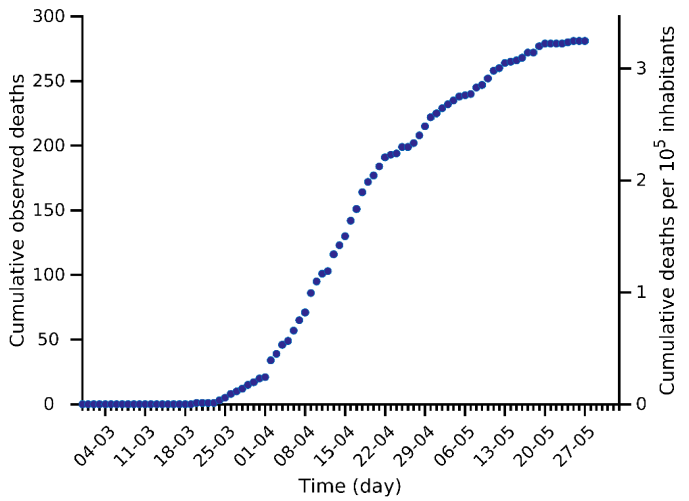


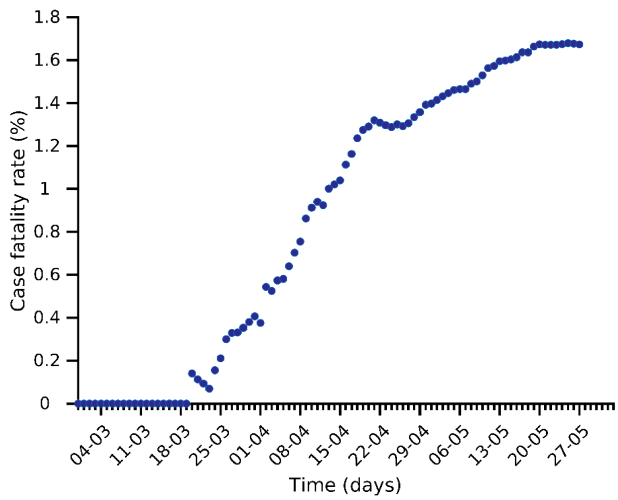




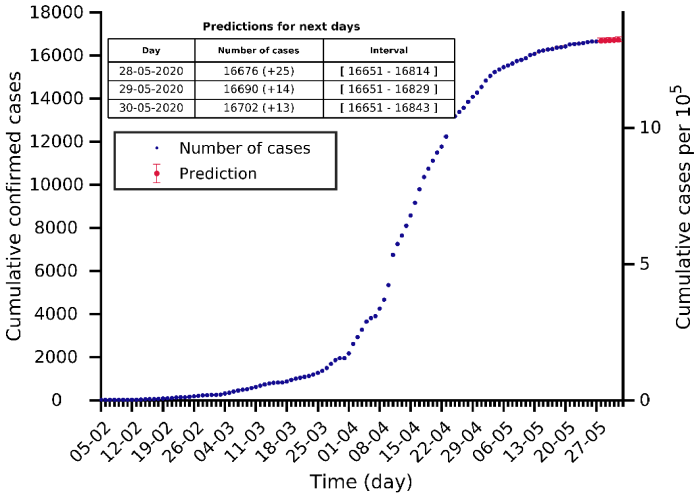


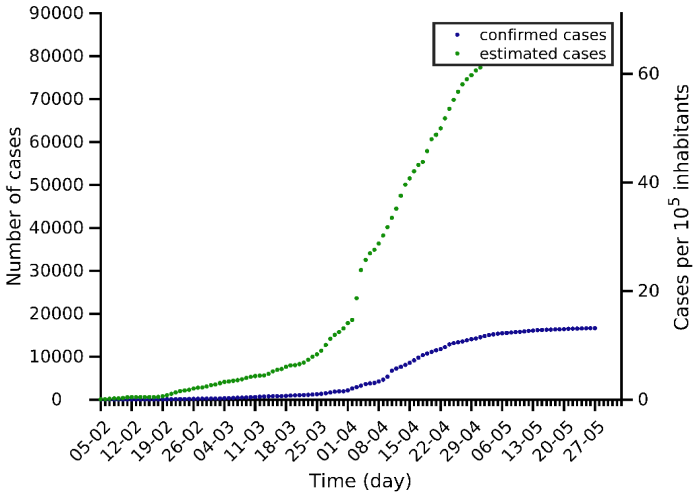


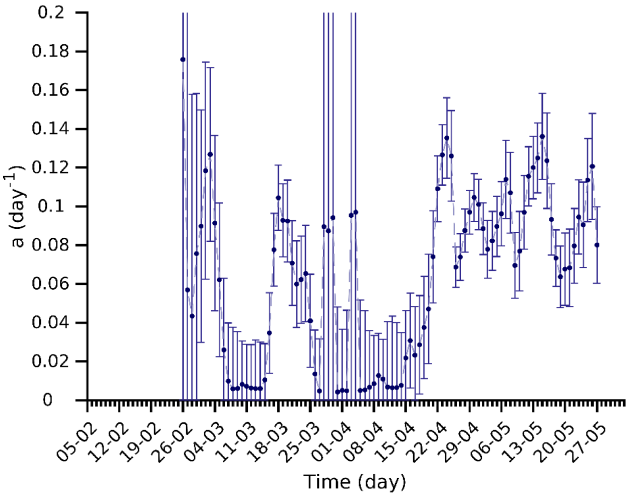


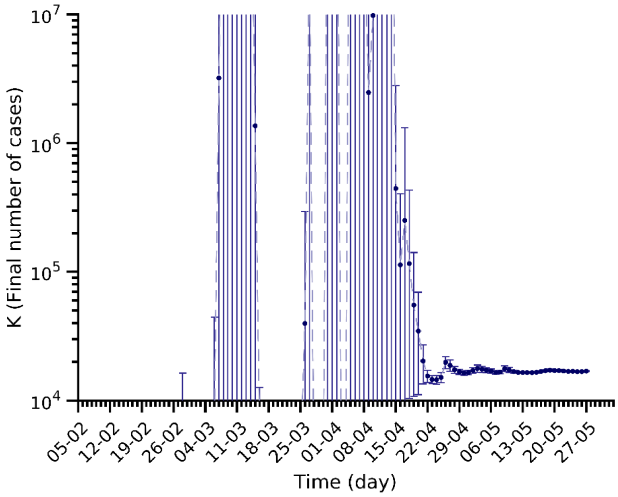


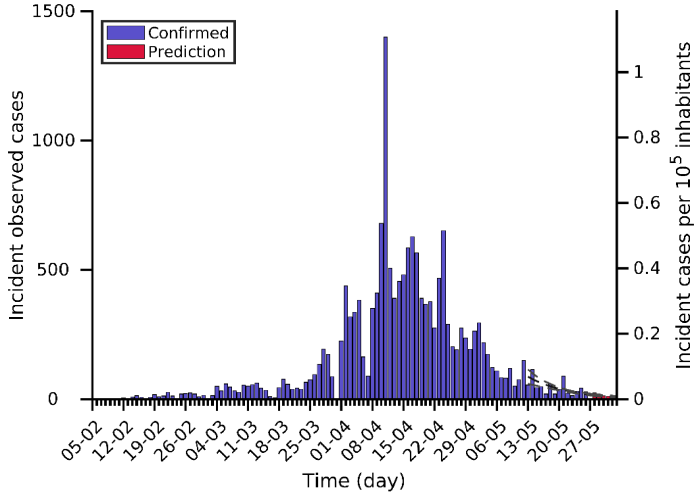
Japan 27-05-2020. Population: 126.5M. Current cumulated incidence: 13/10^5

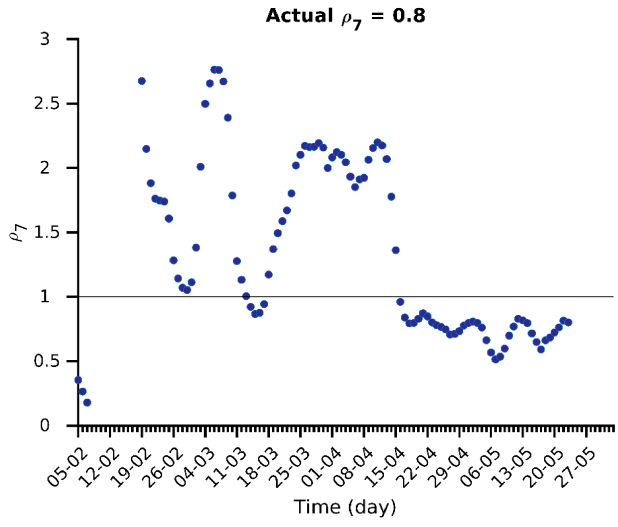


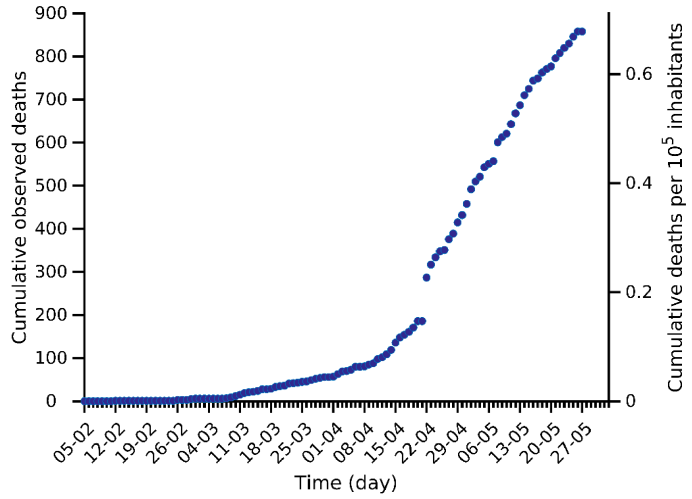


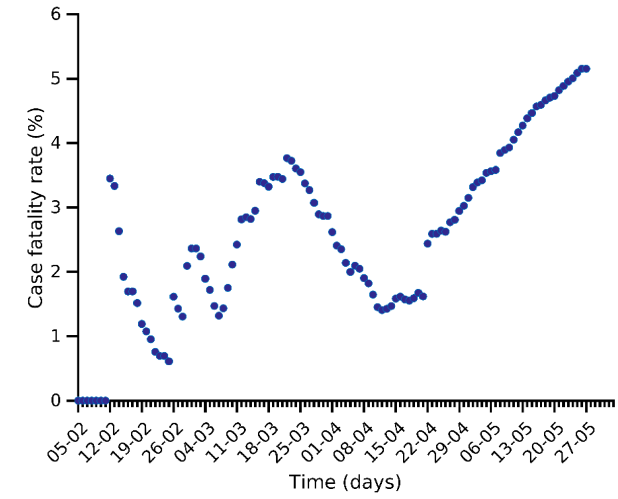




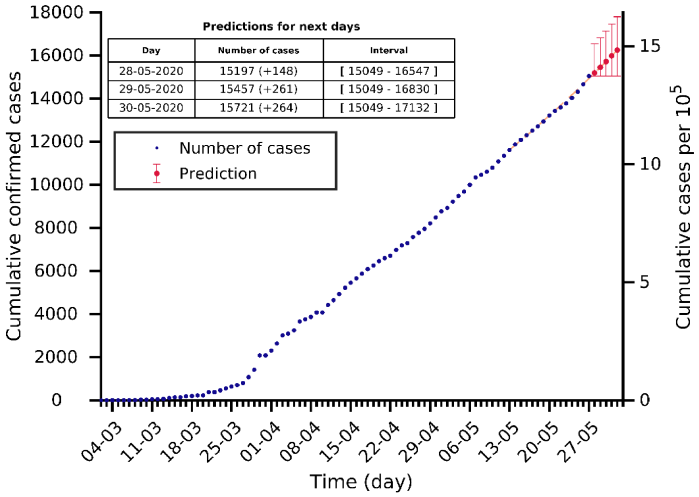


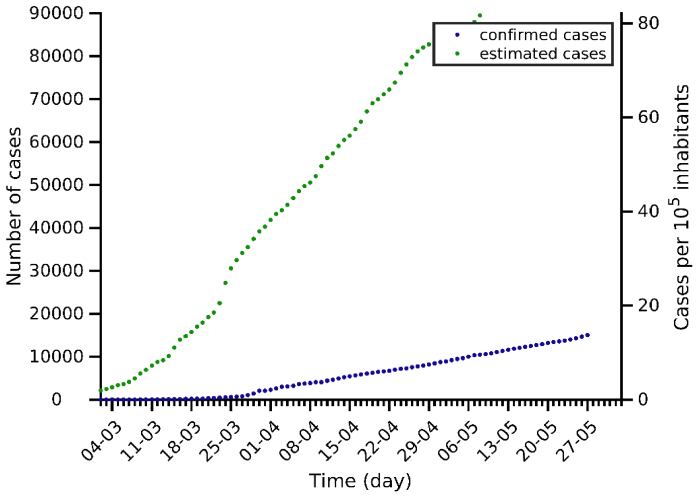


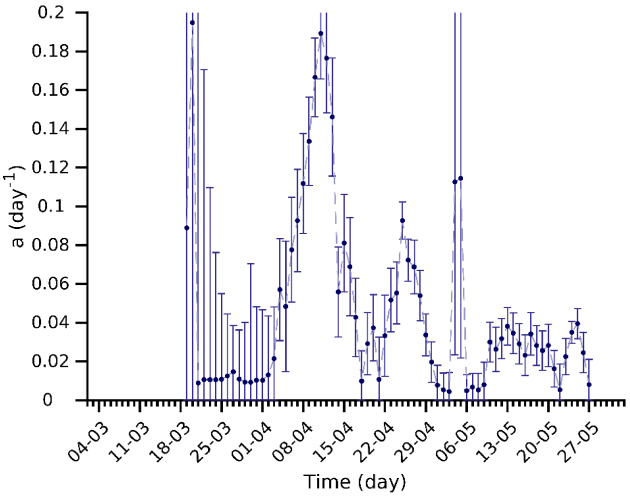


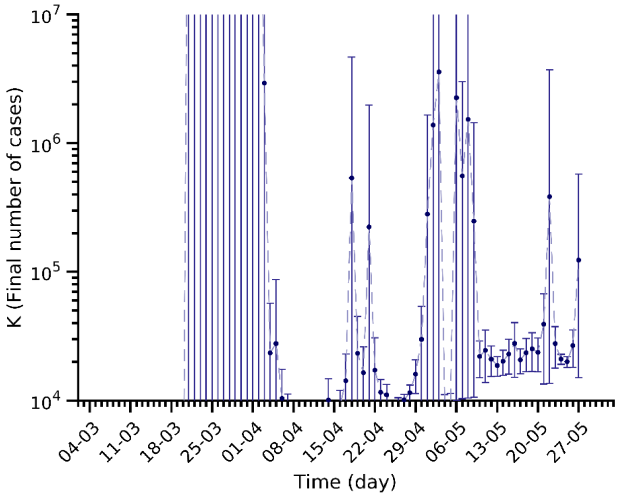


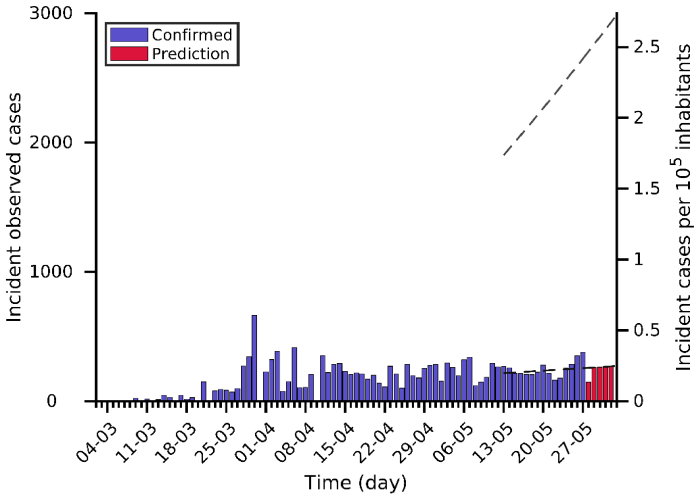
Philippines 27-05-2020. Population: 109.6M. Current cumulated incidence: $14/10^5$

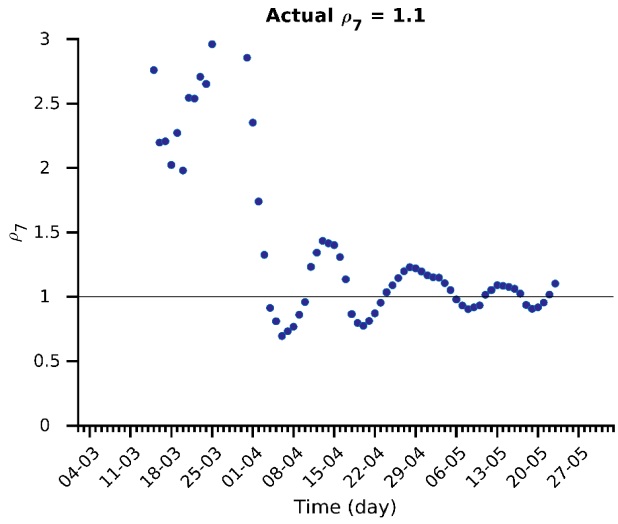


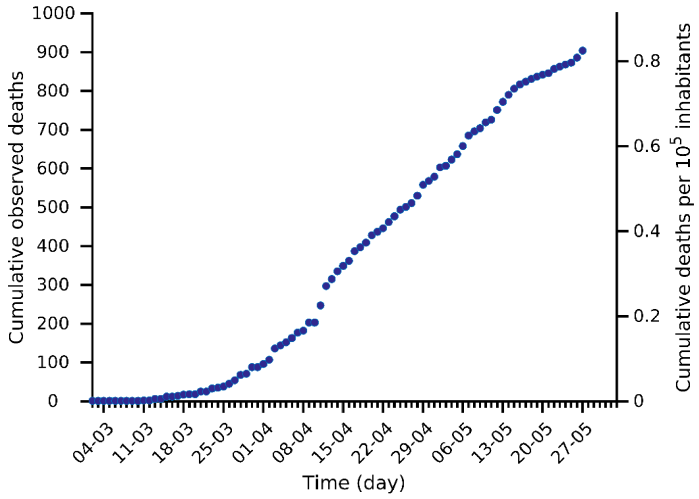


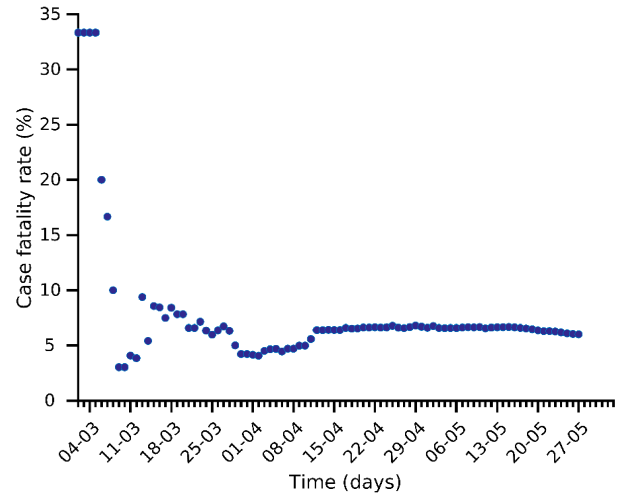




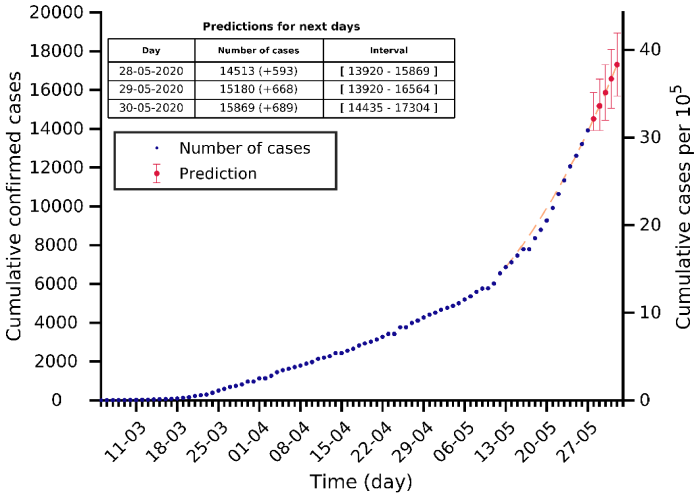


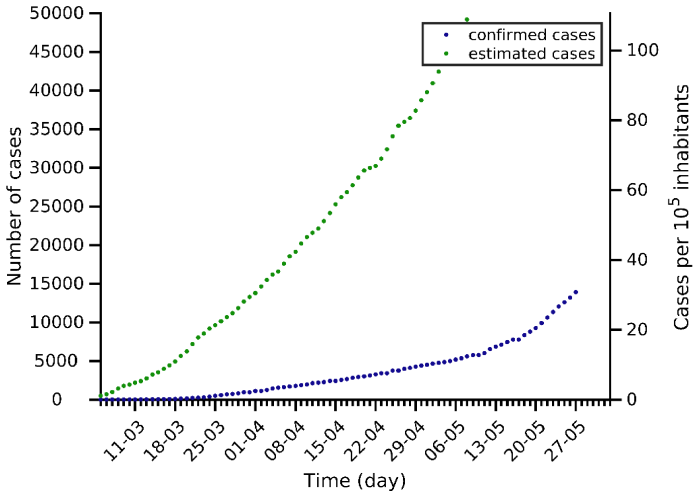


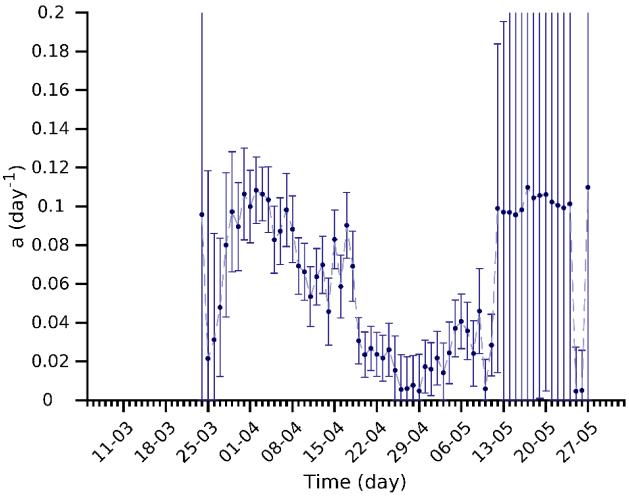


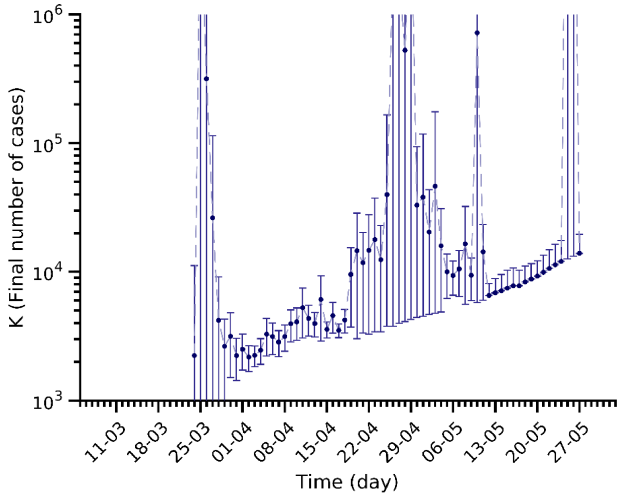


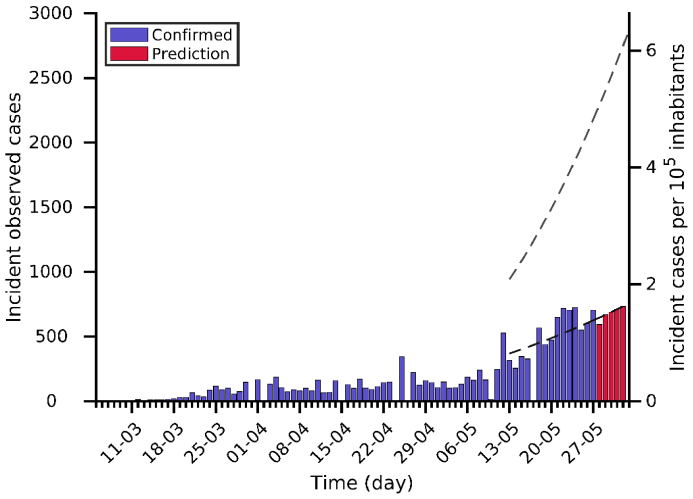
Argentina 27-05-2020. Population: 45.2M. Current cumulated incidence: 31/10^5

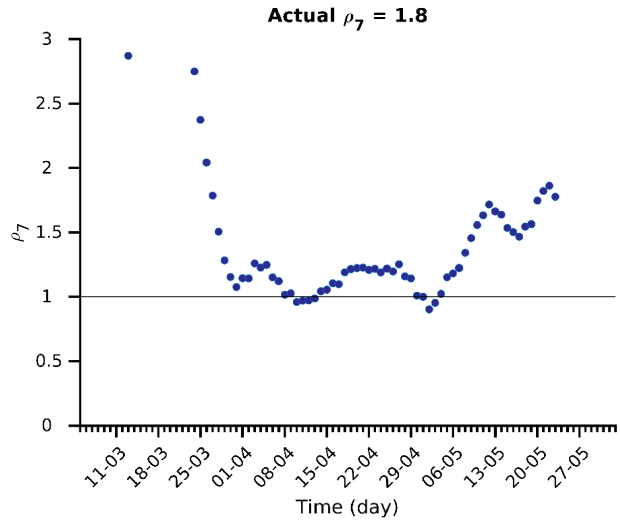


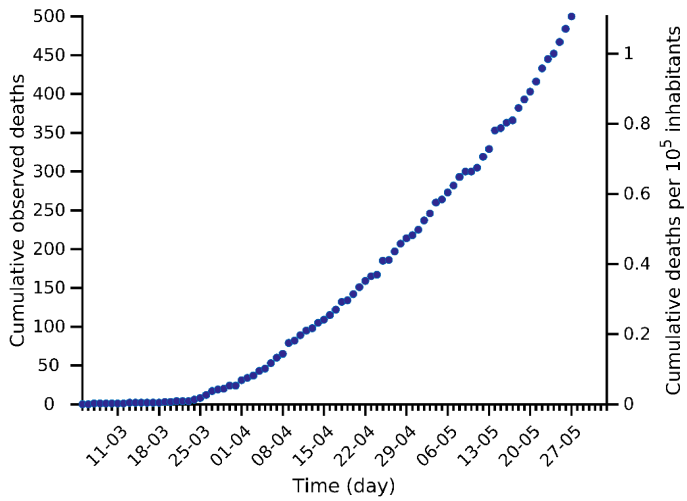


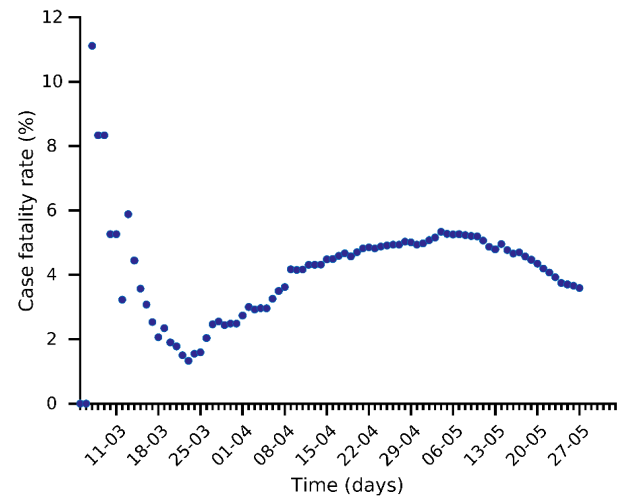




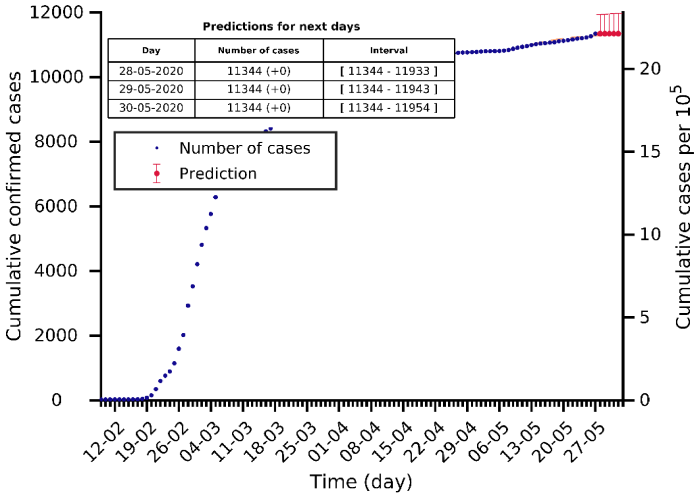


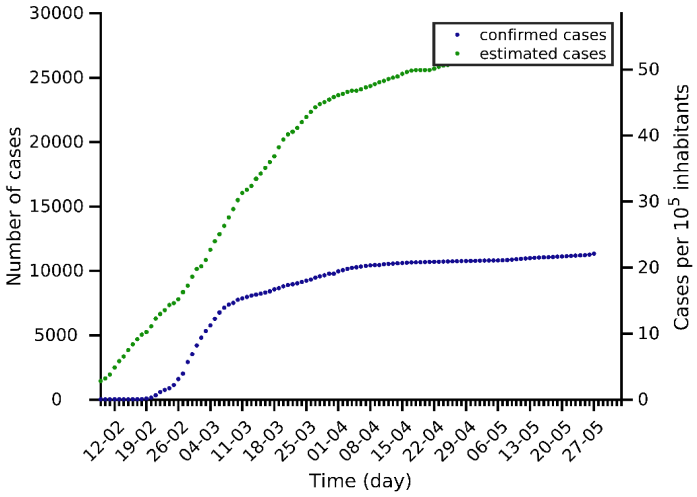


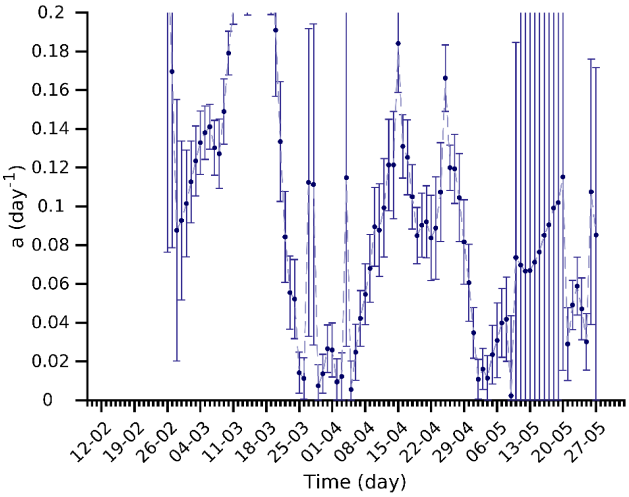


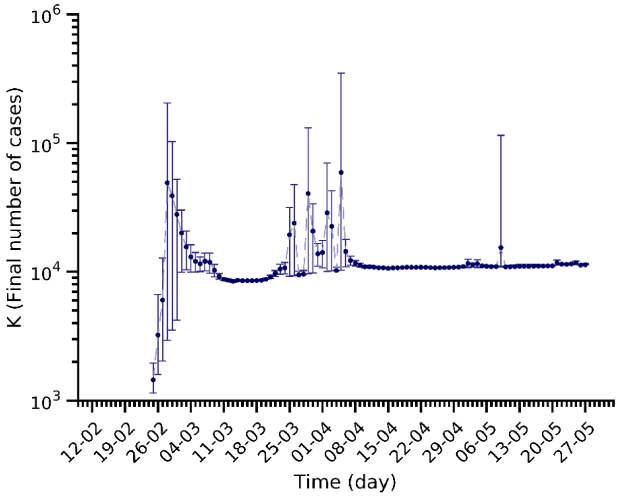


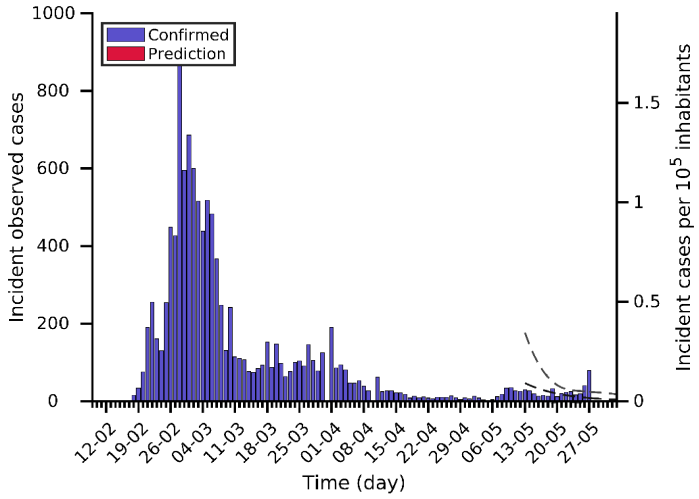
South Korea 27-05-2020. Population: 51.3M. Current cumulated incidence: $22/10^5$

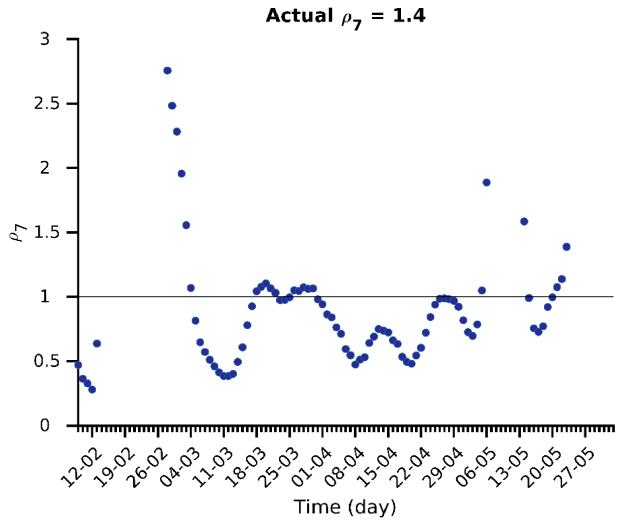


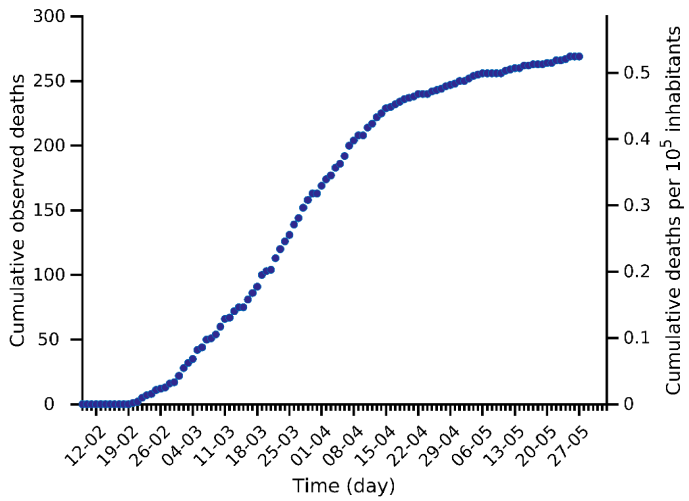


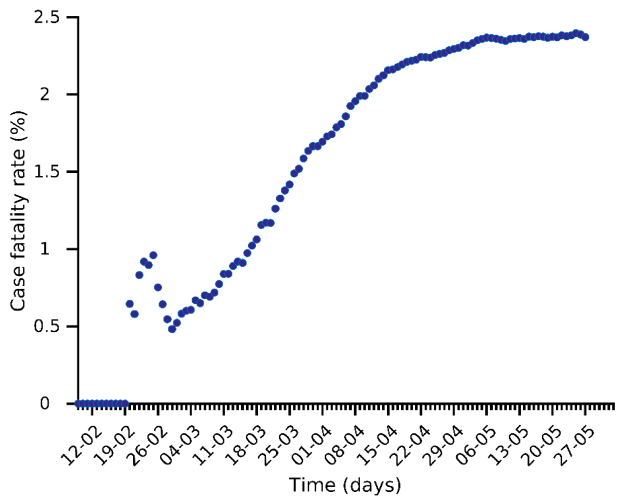




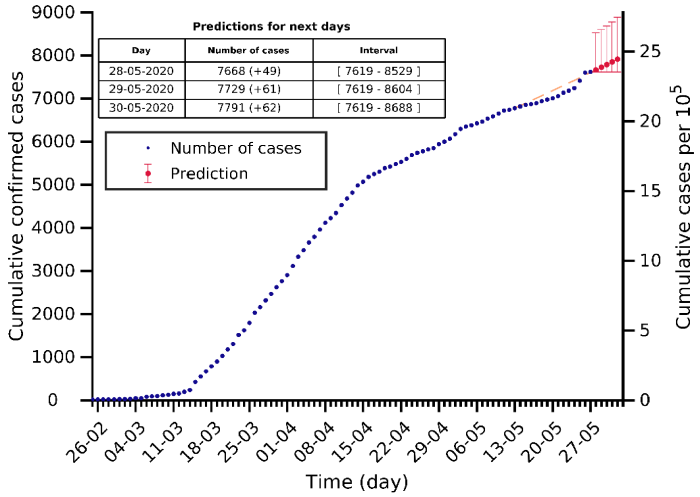


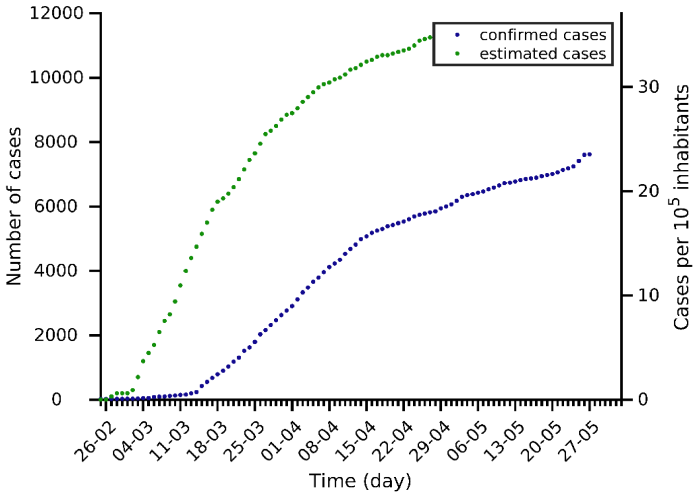


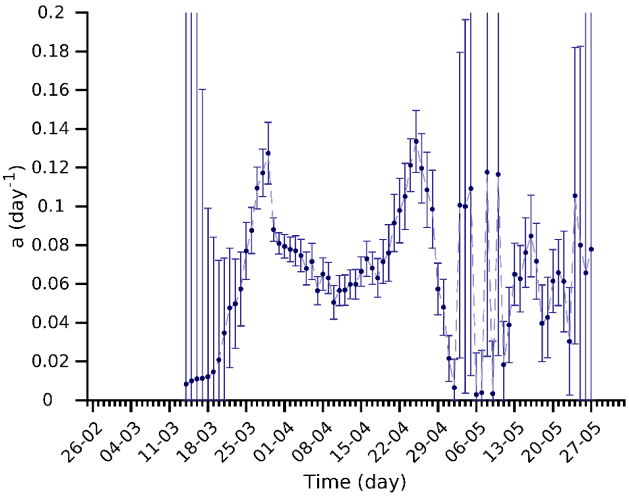


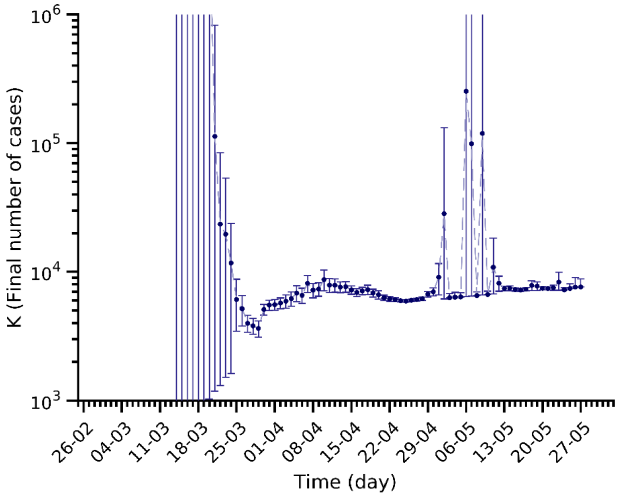


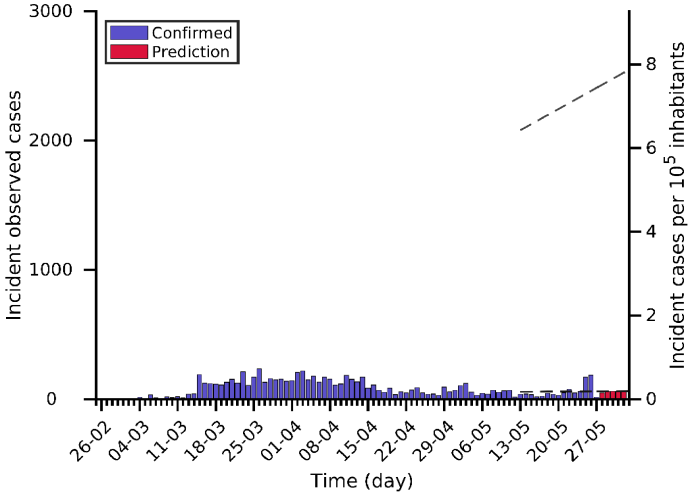
Malaysia 27-05-2020. Population: 32.4M. Current cumulated incidence: 24/10^5

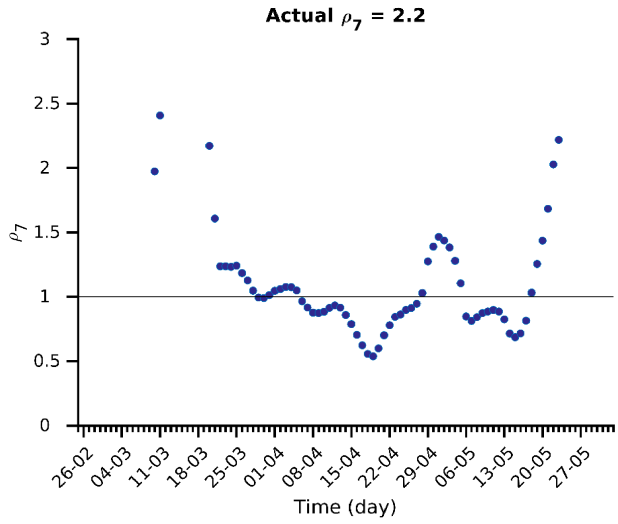


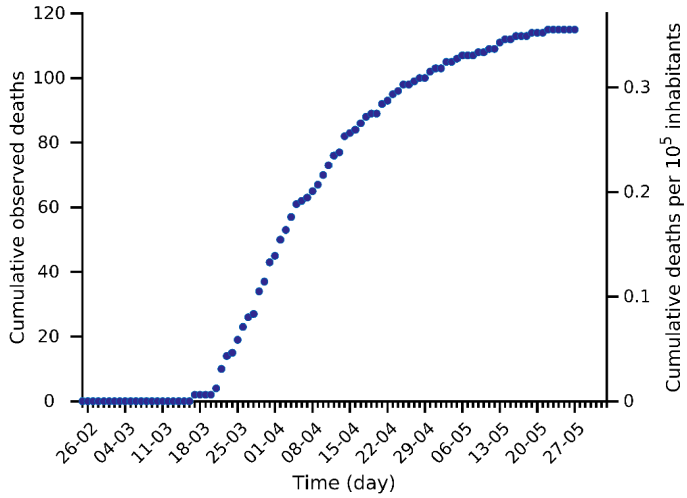


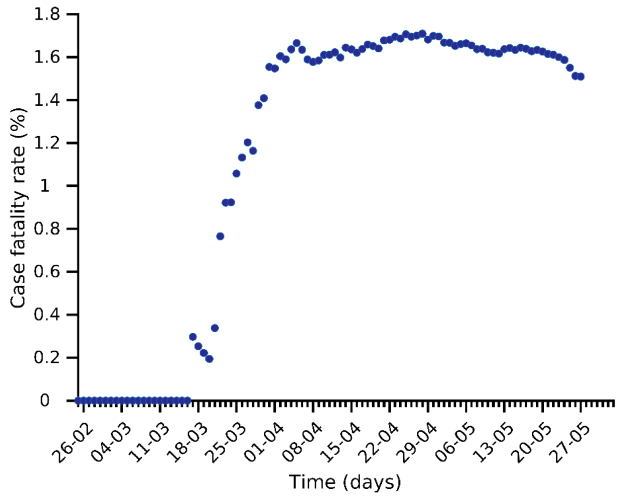




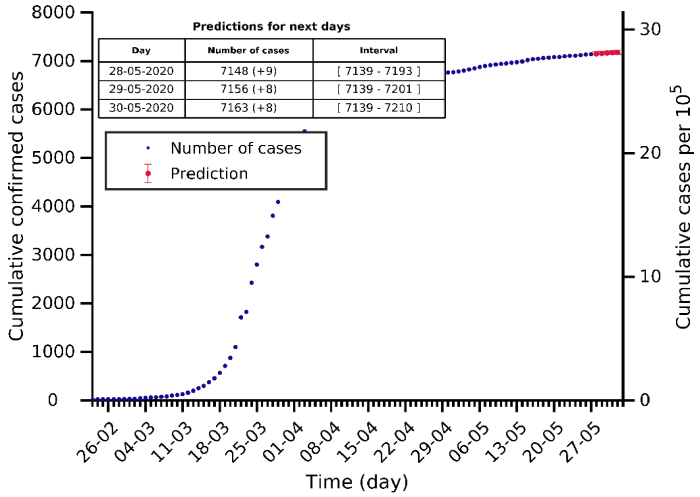


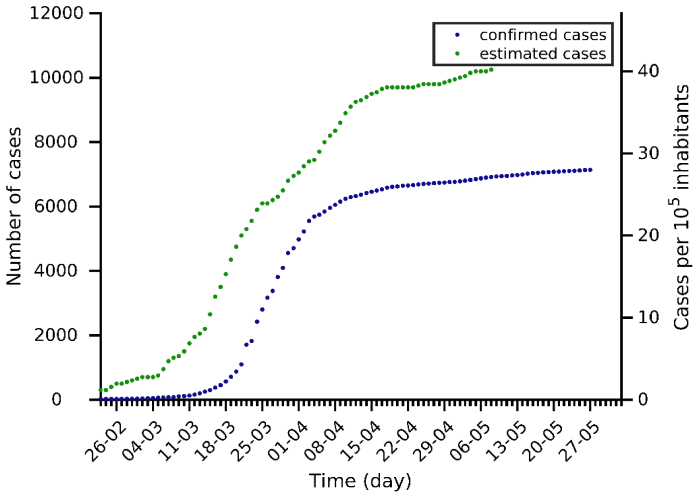


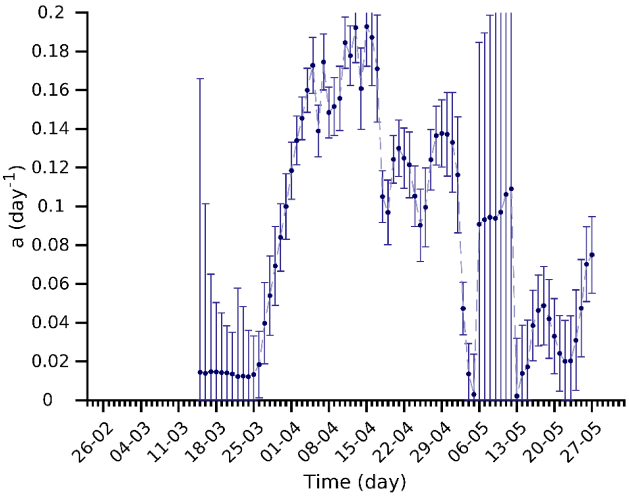


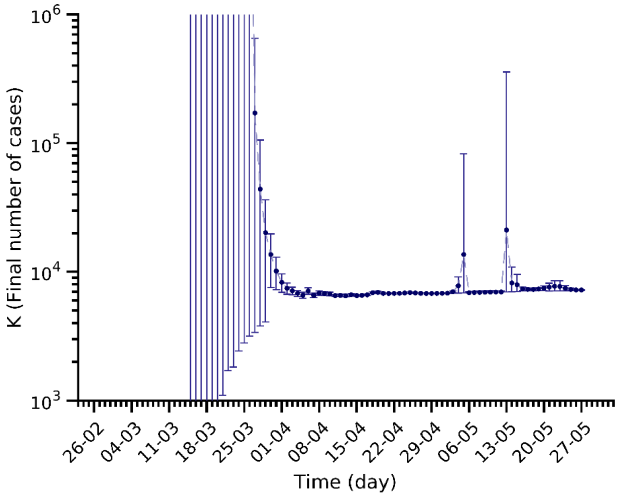


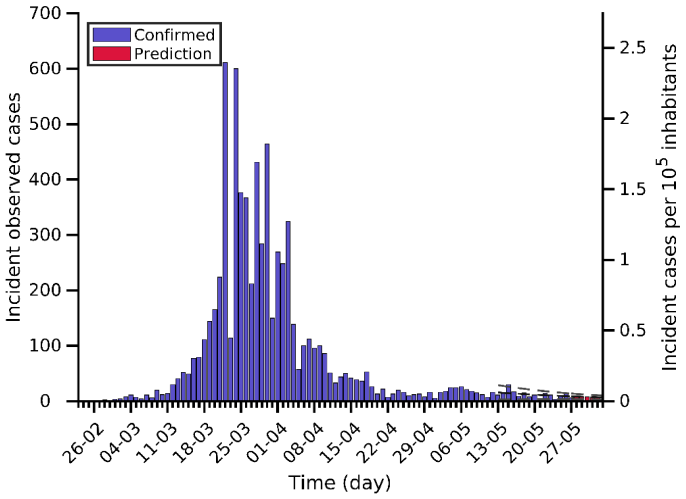
Australia 27-05-2020. Population: 25.5M. Current cumulated incidence: $28/10^5$

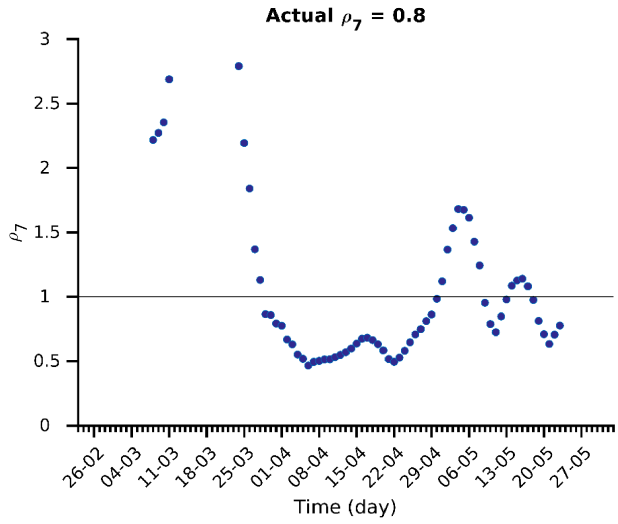


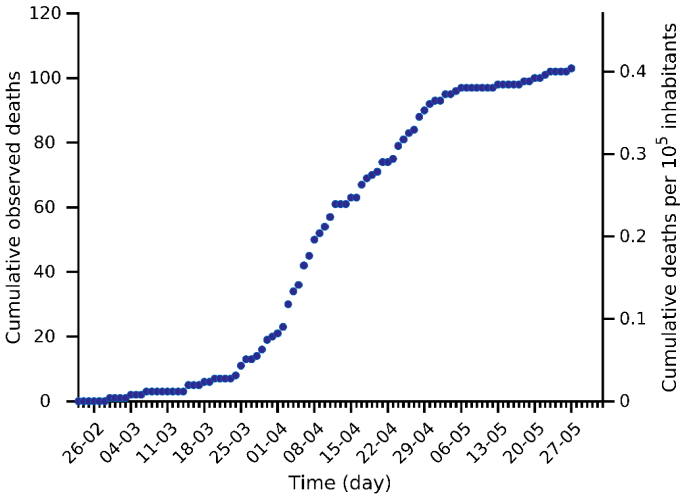


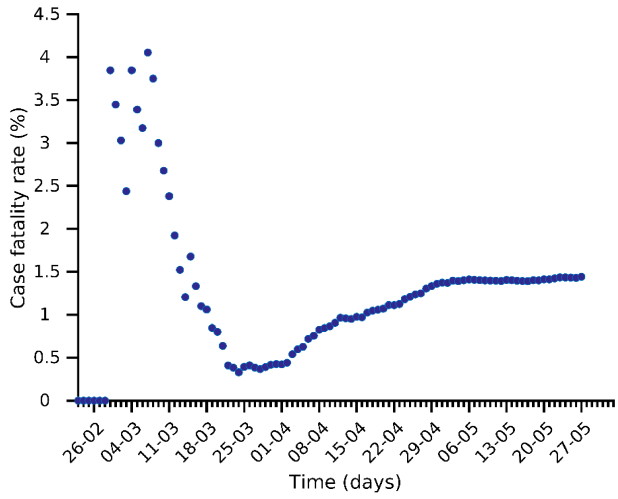




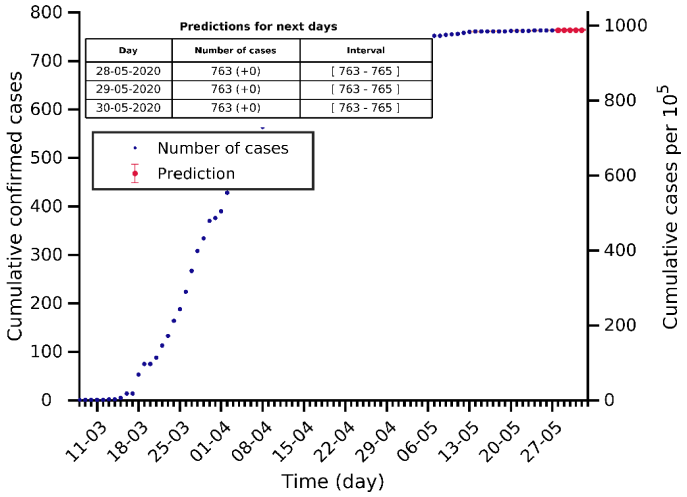


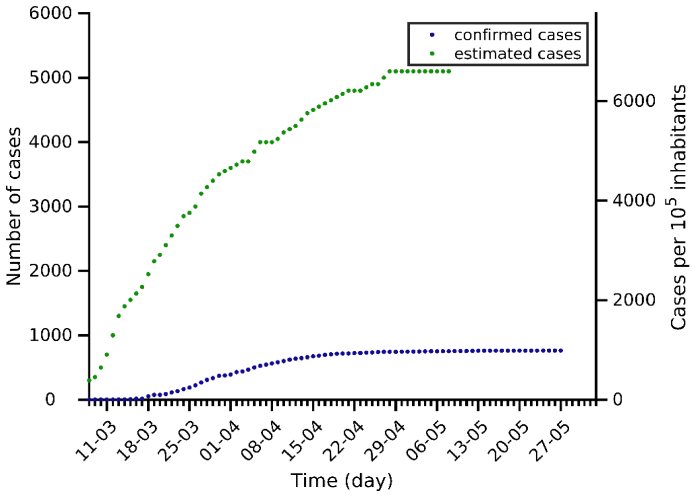


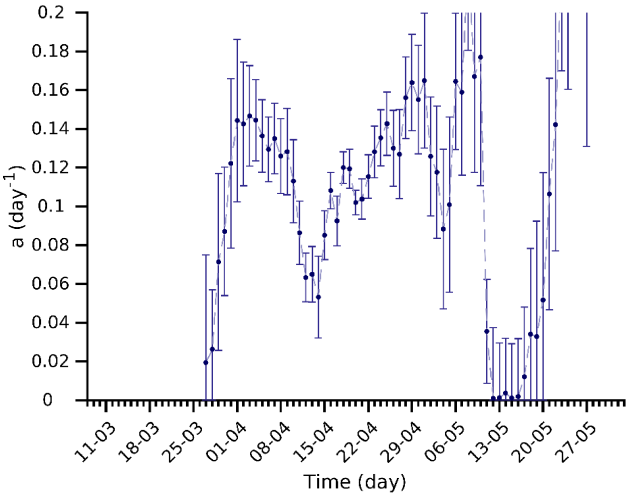


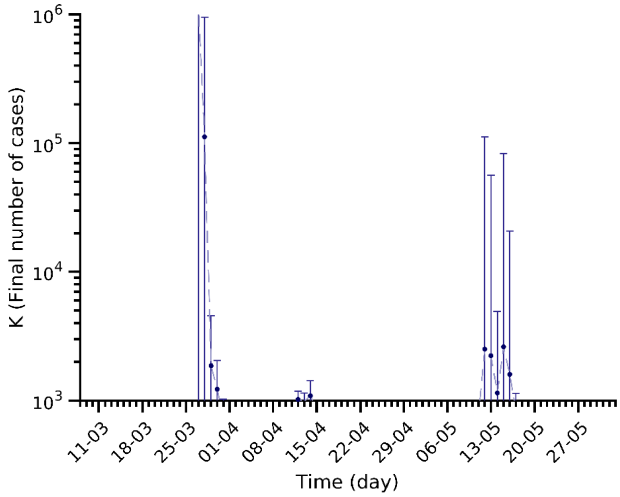


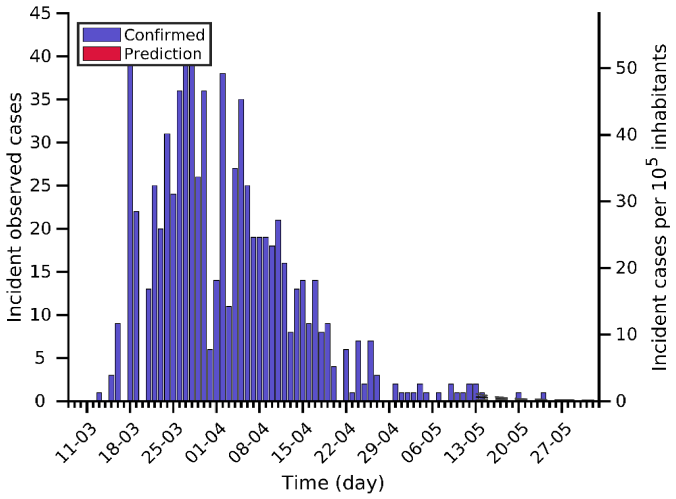
Andorra 27-05-2020. Population: 0.1M. Current cumulated incidence: 988/10^5

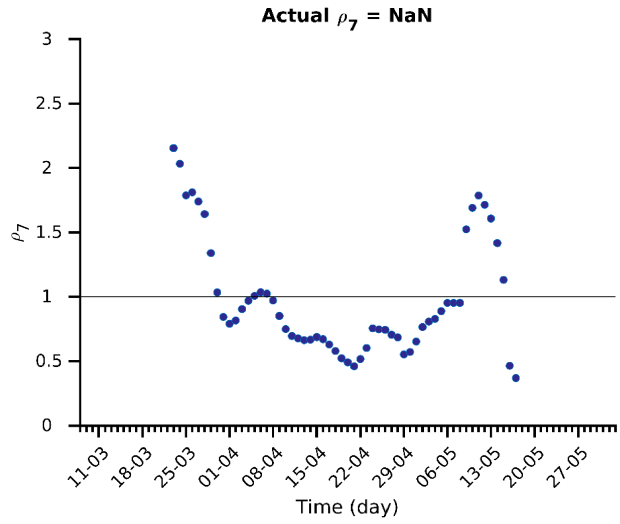


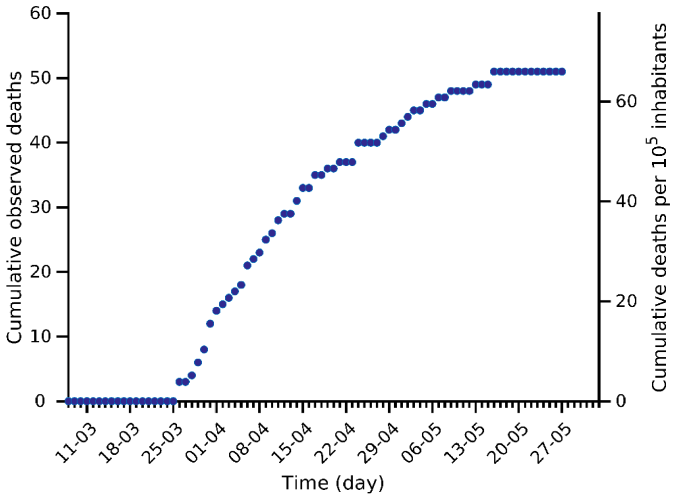


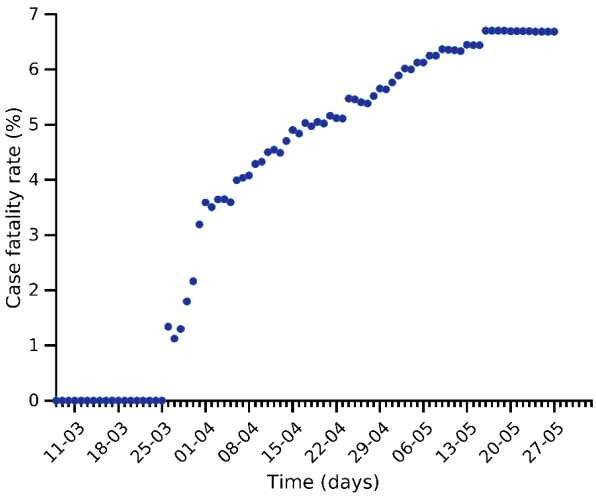








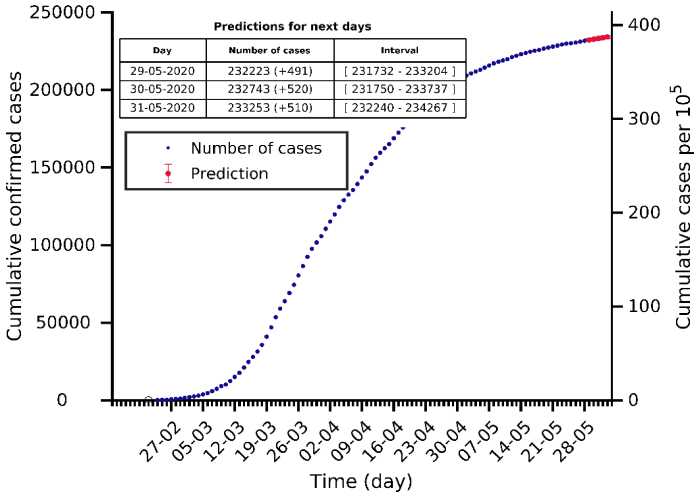


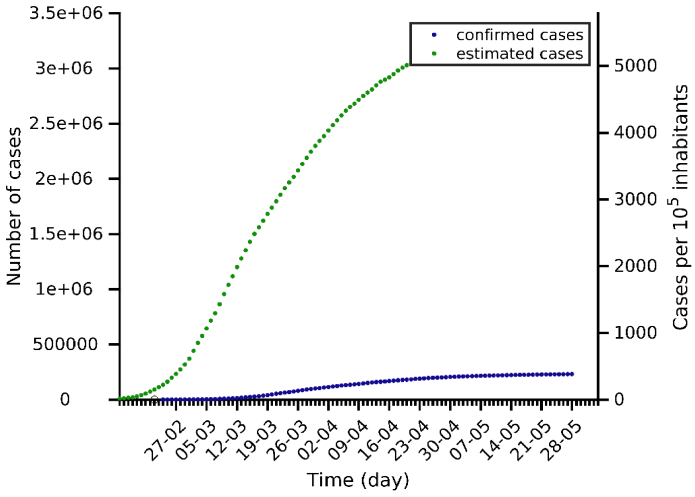


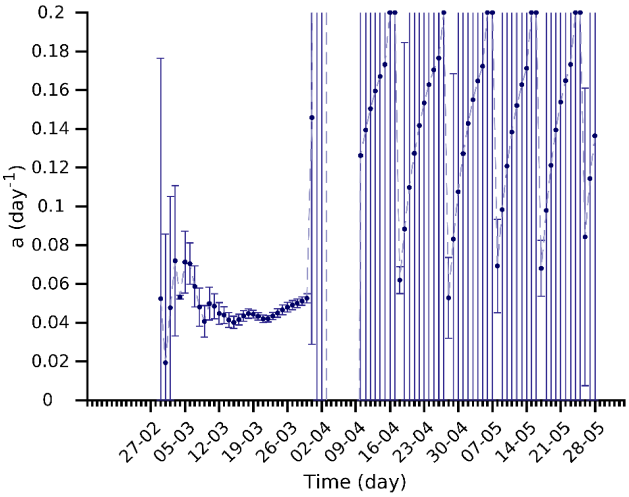
(3) Analysis and prediction of COVID-19 for Italy and its regions

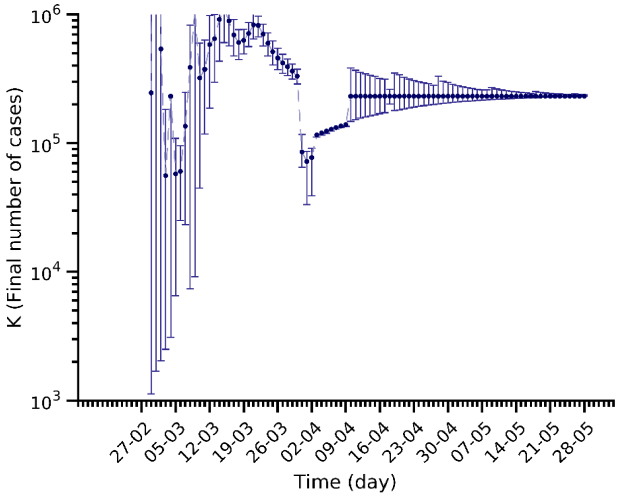
Data obtained from: https://github.com/pcm-dpc/COVID-19/tree/master/dati-andamento-nazionale

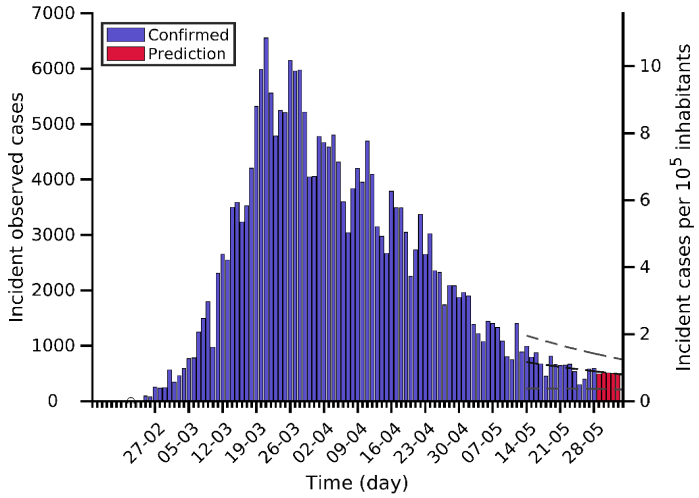
Italy 28-05-2020. Population: 60.5M. Current cumulated incidence: 383/10^5

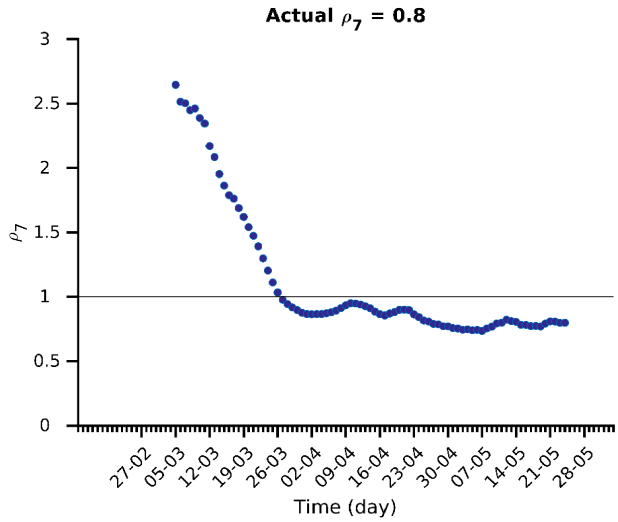


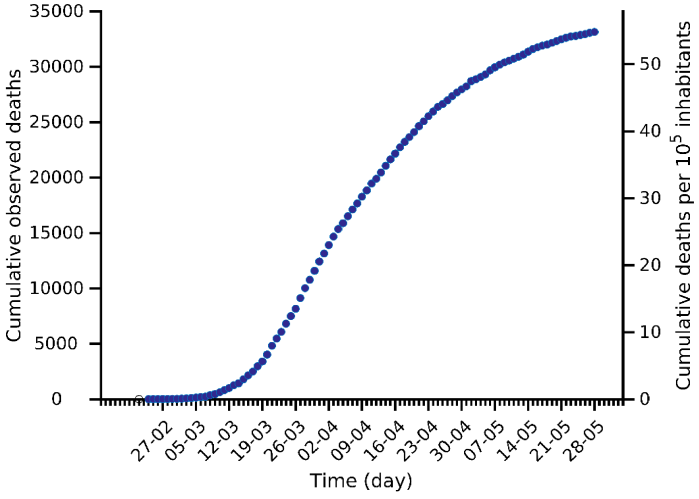


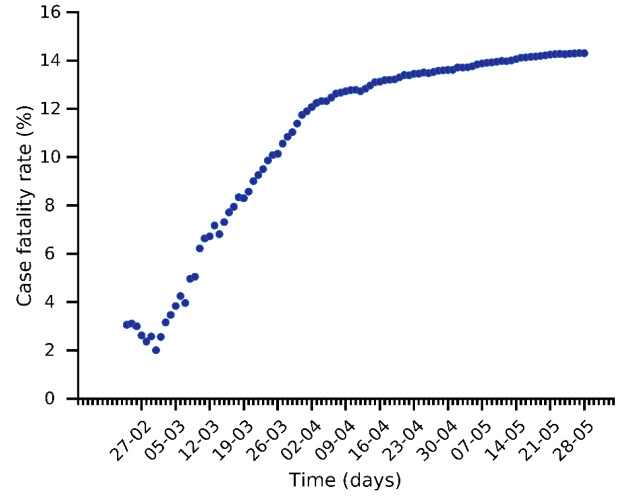




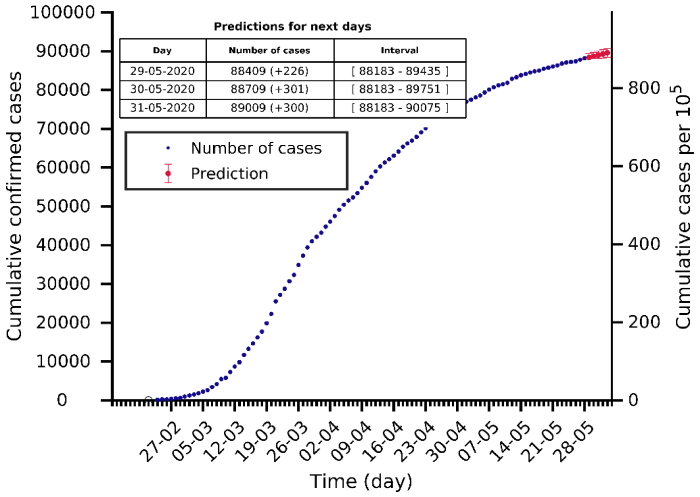


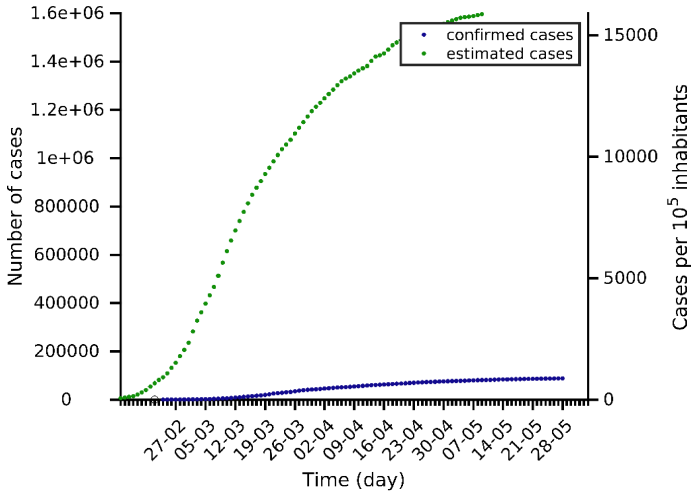


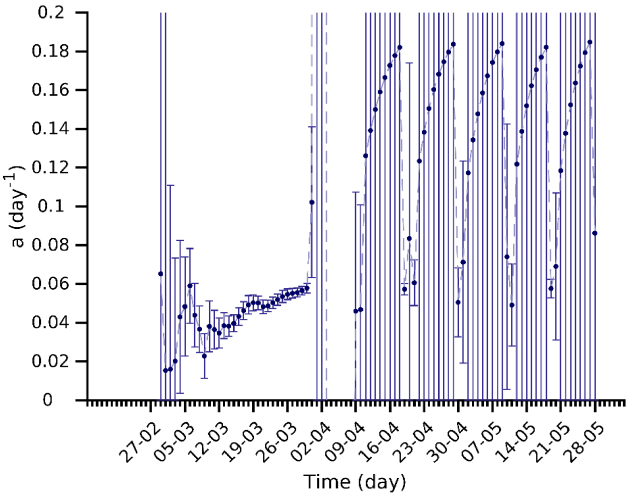


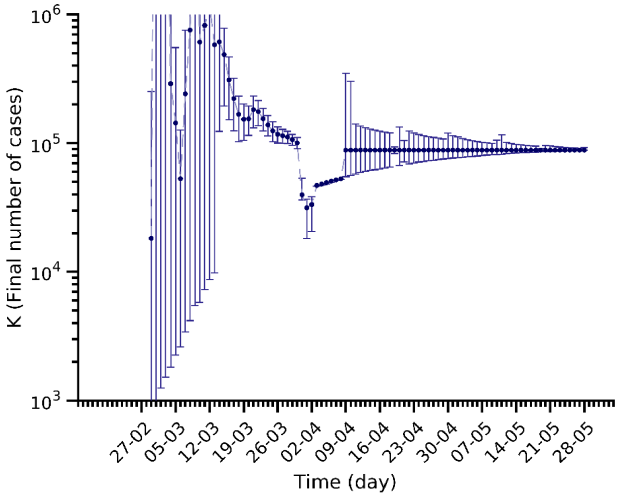


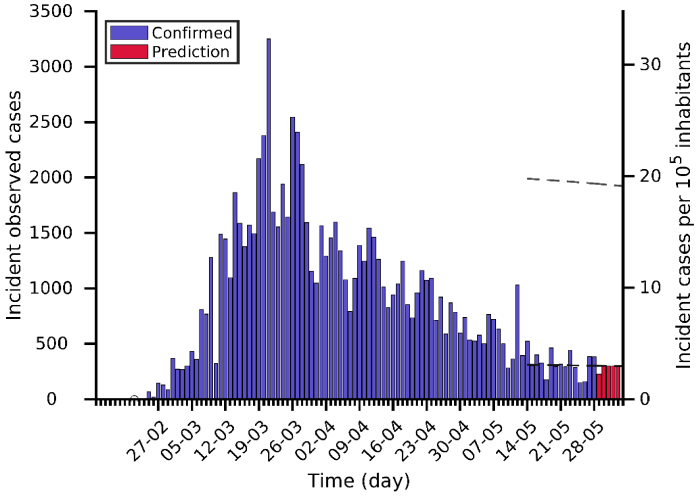
Lombardia 28-05-2020. Population: 10.1M. Current cumulated incidence: 876/10^5

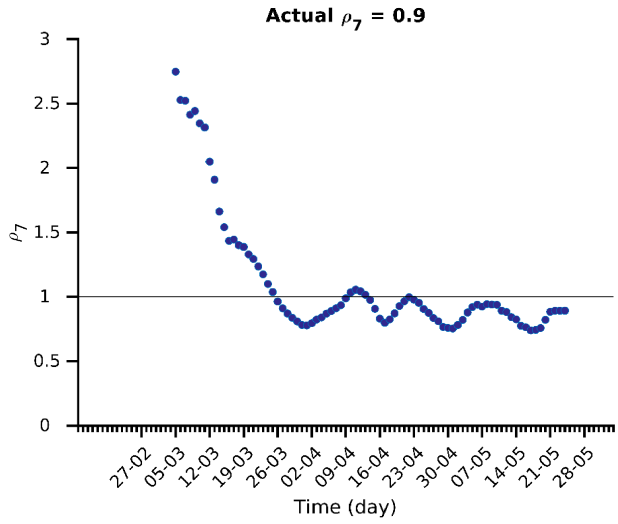


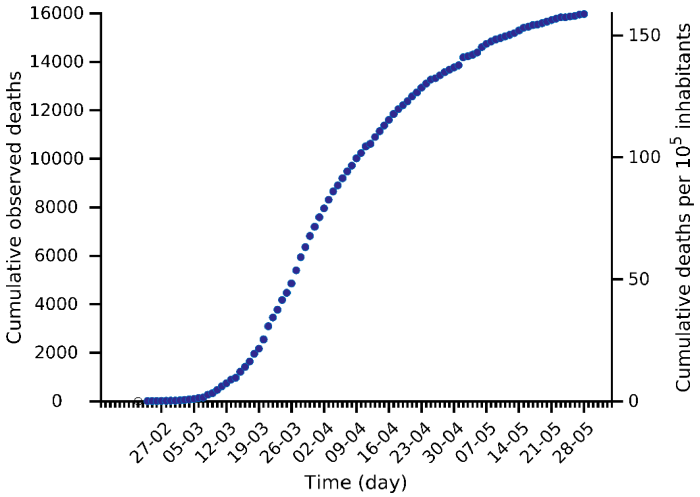


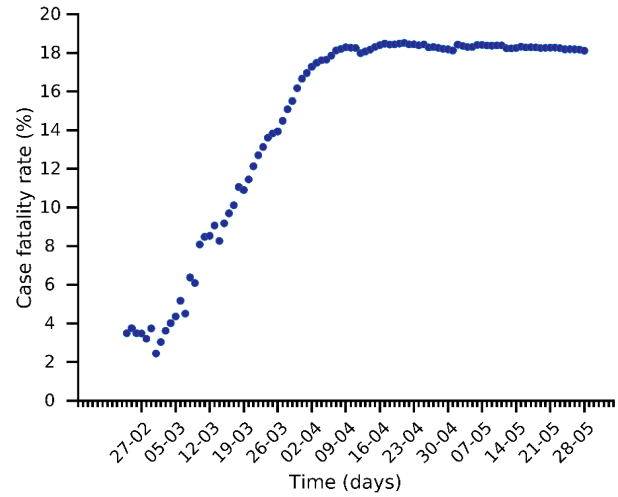




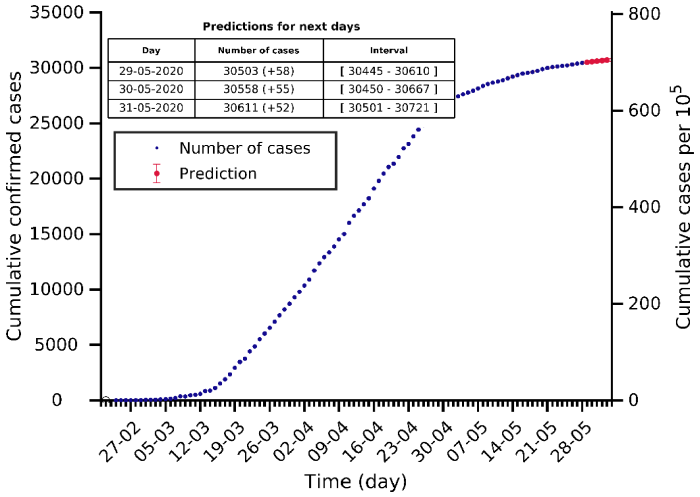


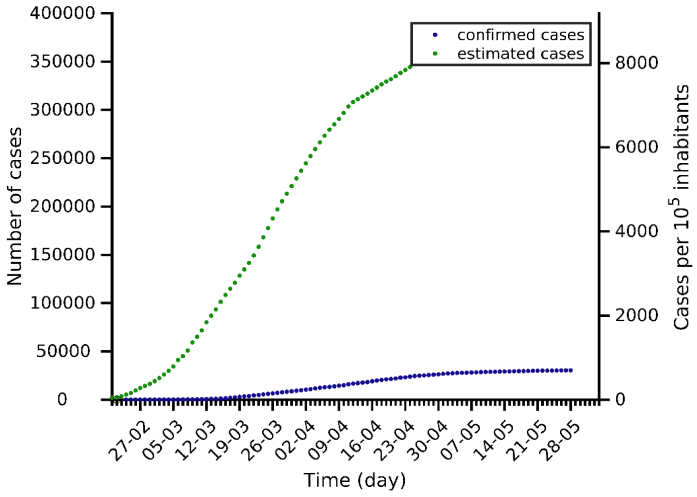


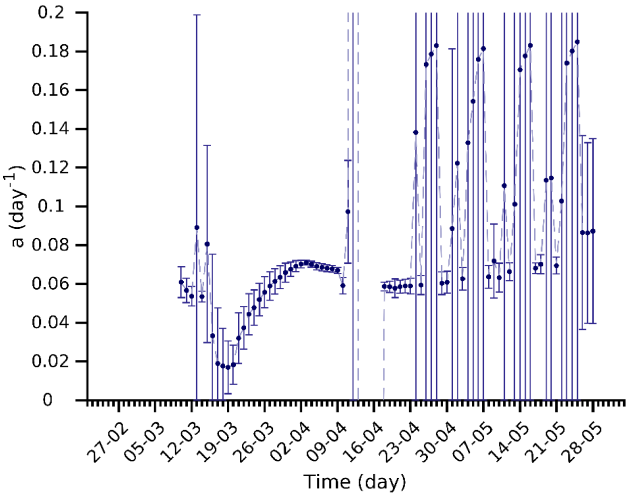


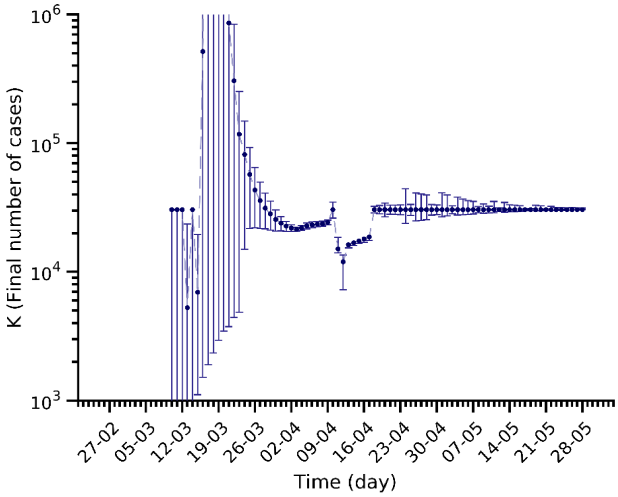


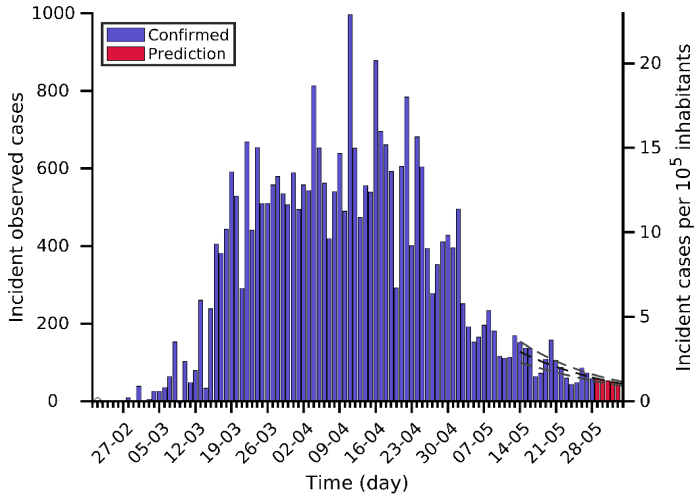
Piemonte 28-05-2020. Population: 4.4M. Current cumulated incidence: 699/10⁵

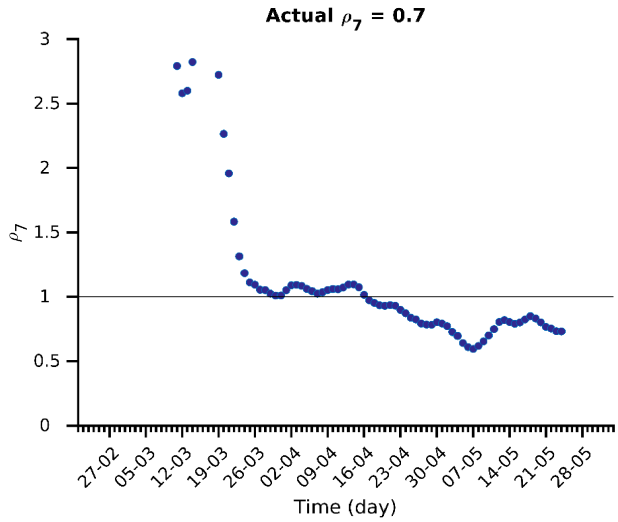


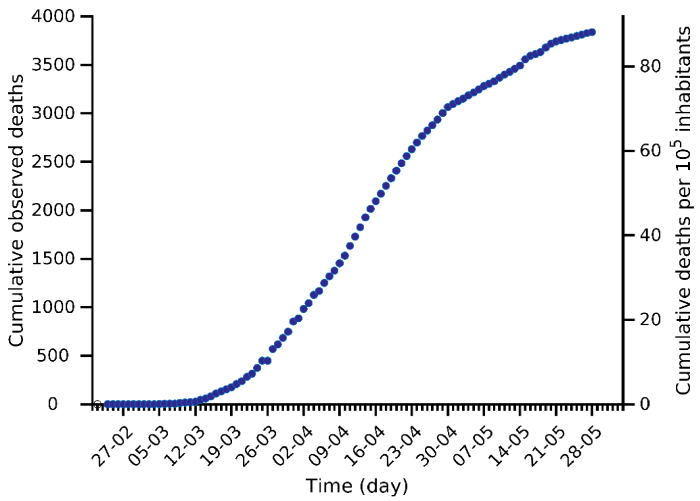


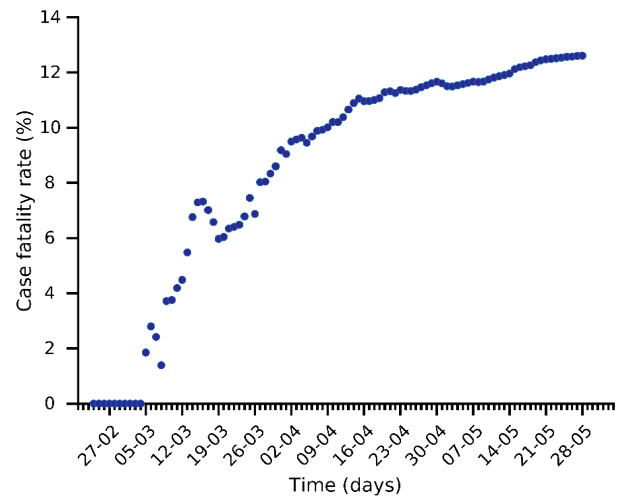




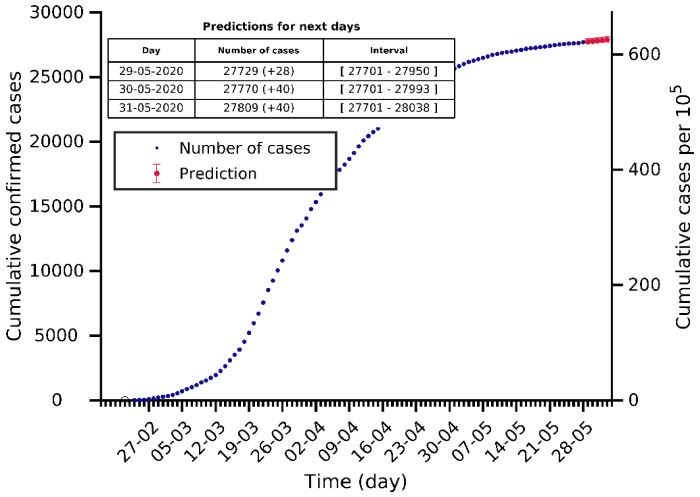


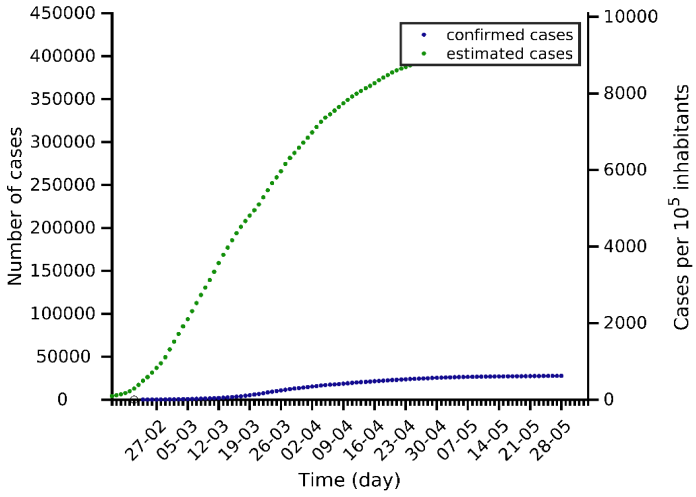


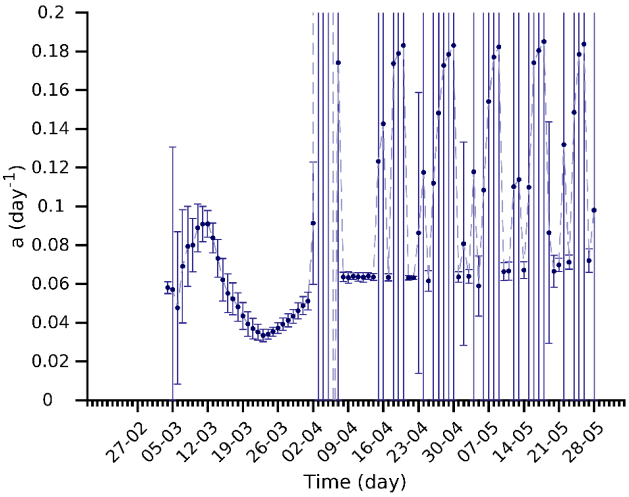


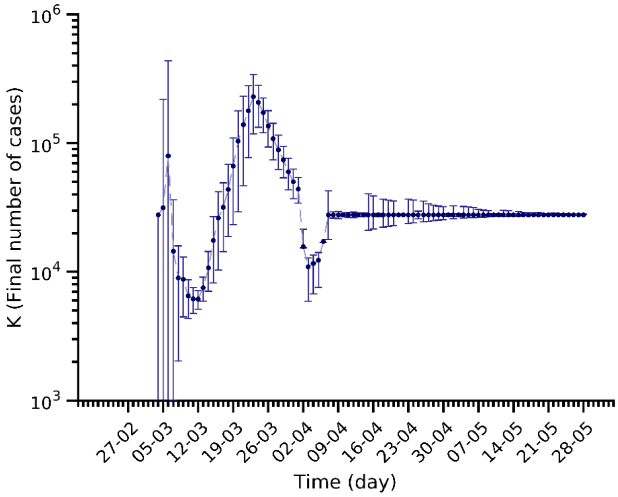


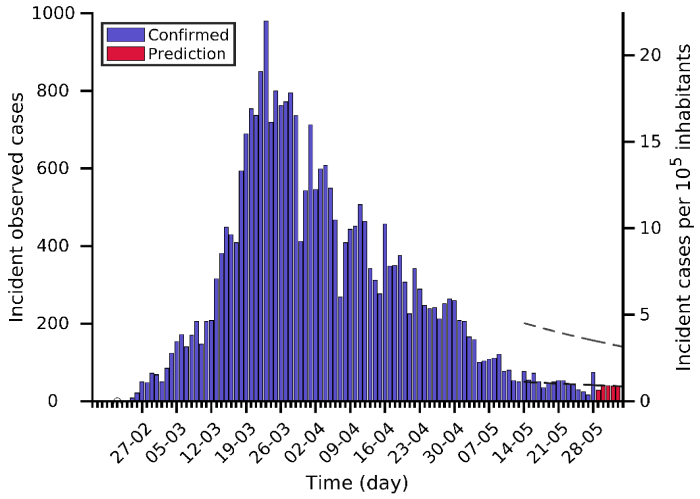
Emilia Romagna 28-05-2020. Population: 4.5M. Current cumulated incidence: 621/1

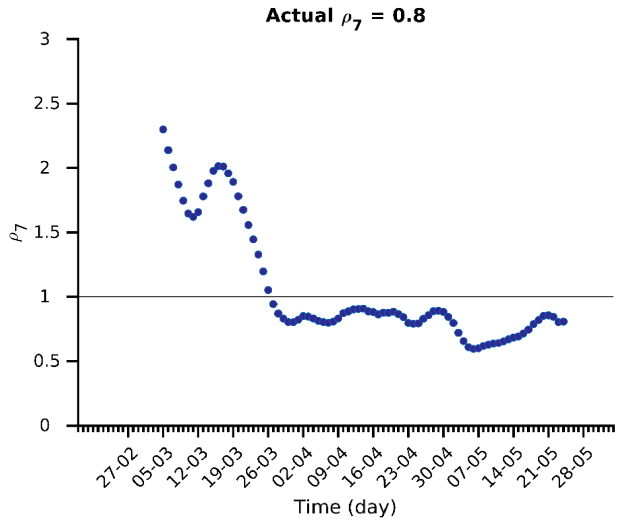


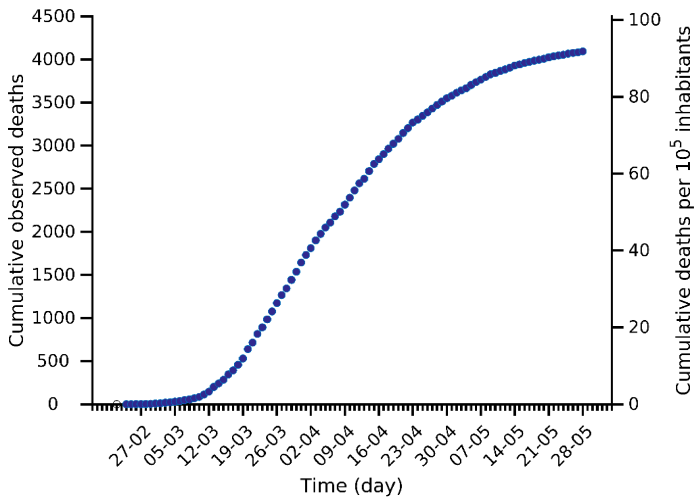


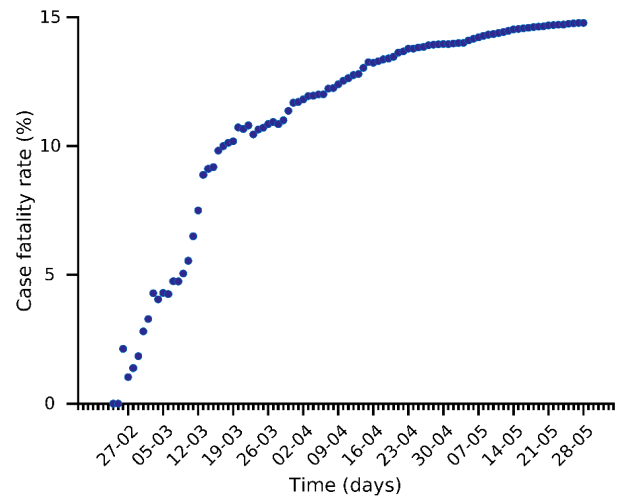




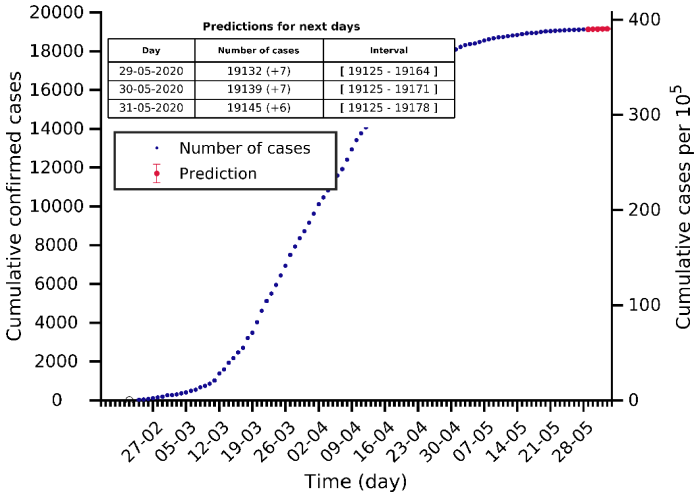


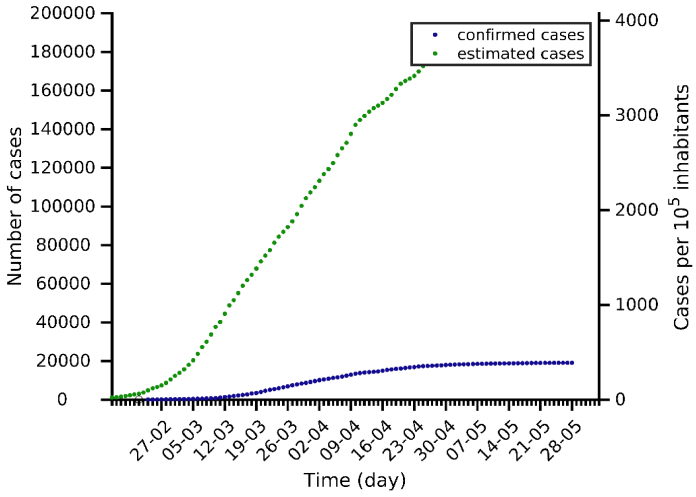


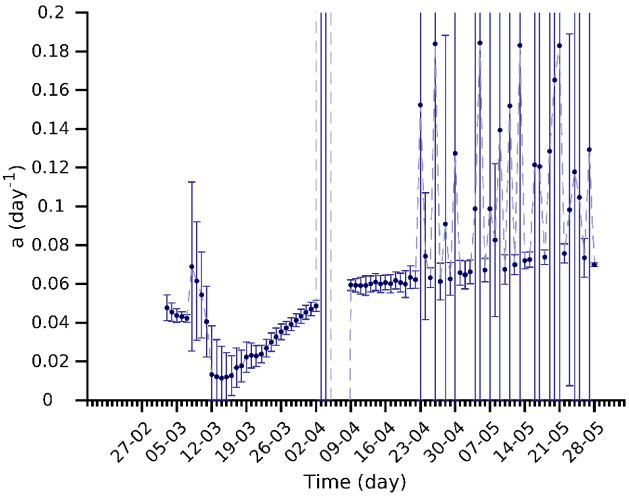


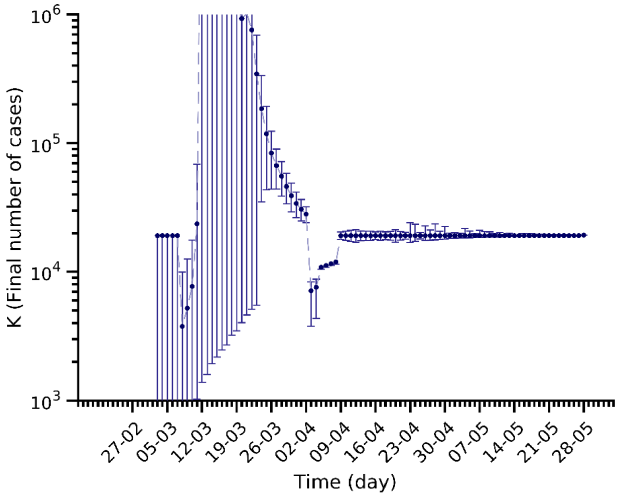


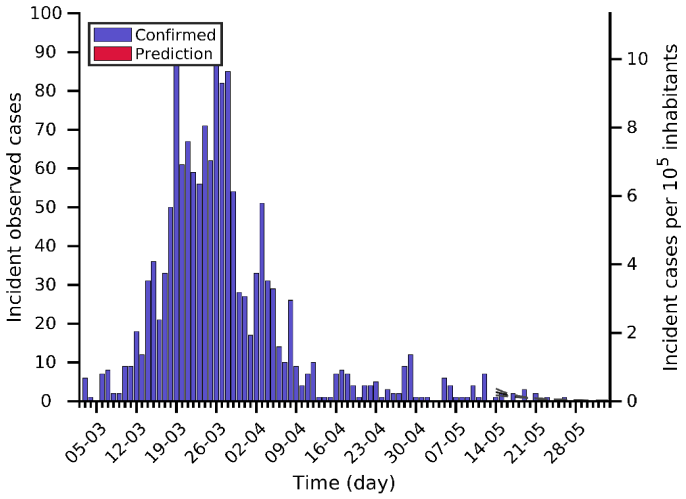
Veneto 28-05-2020. Population: 4.9M. Current cumulated incidence: $390/10^5$

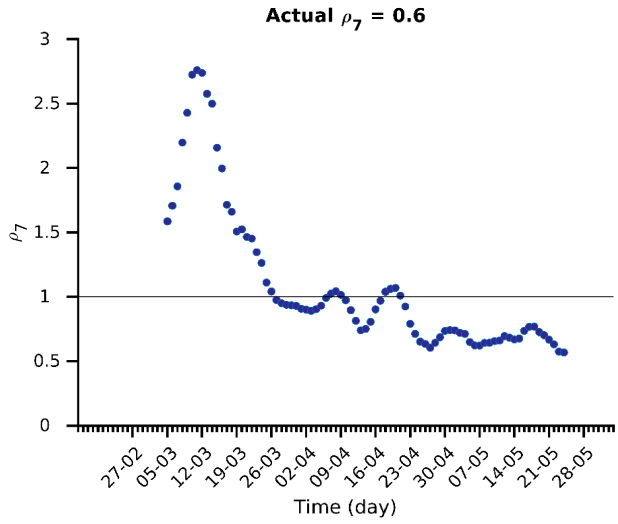


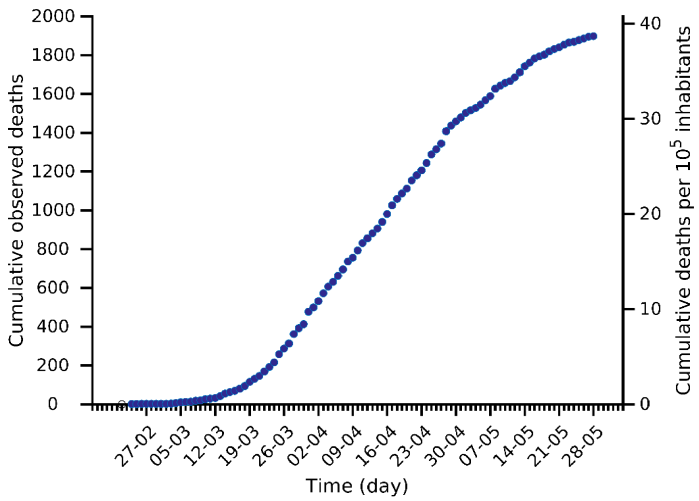


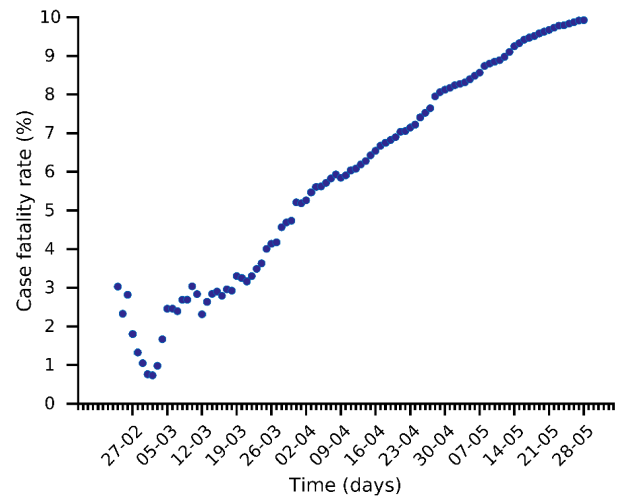




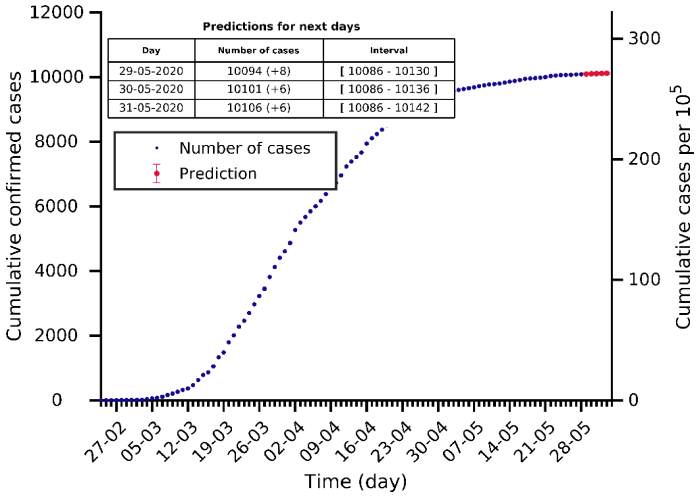


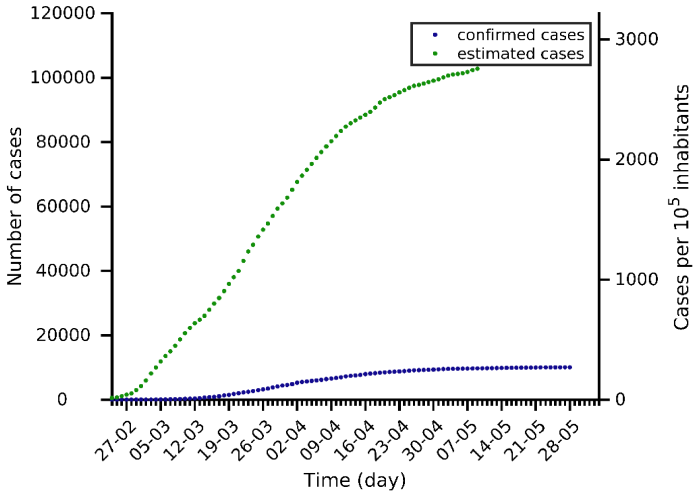


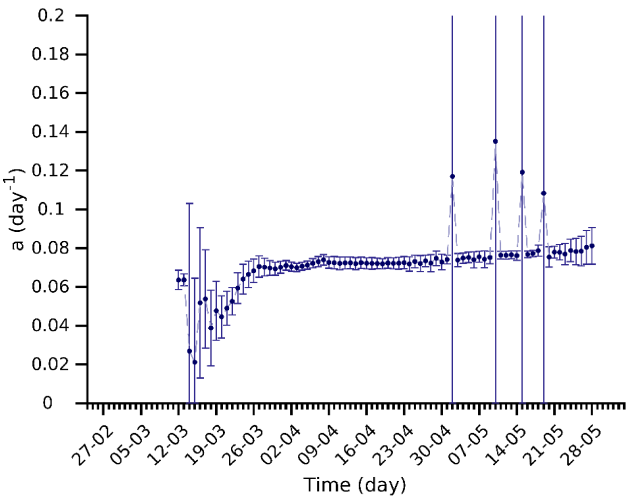


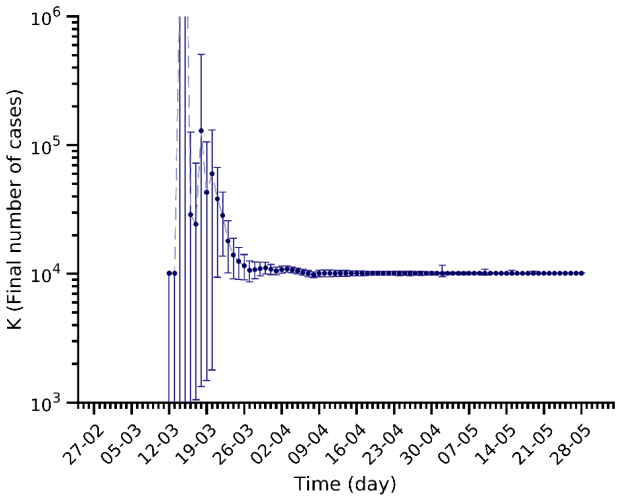


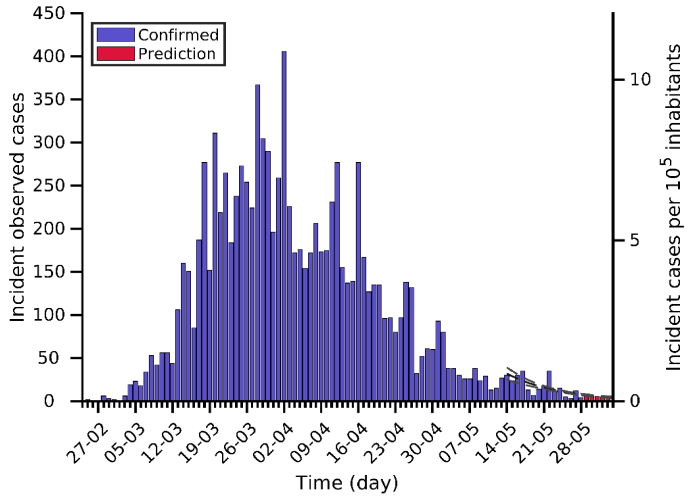
Toscana 28-05-2020. Population: 3.7M. Current cumulated incidence: 270/10⁵

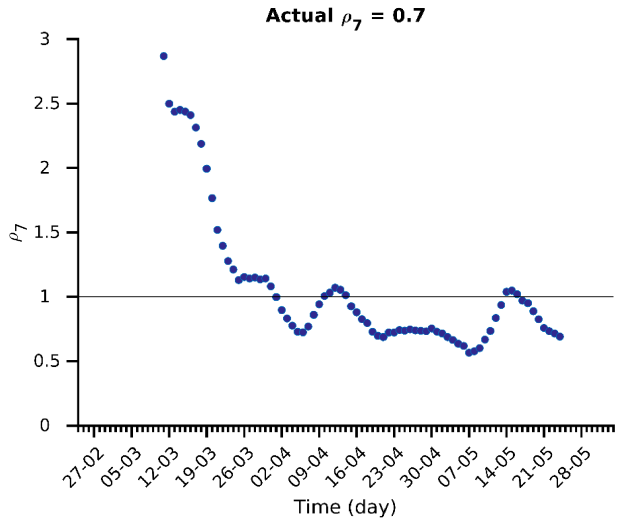


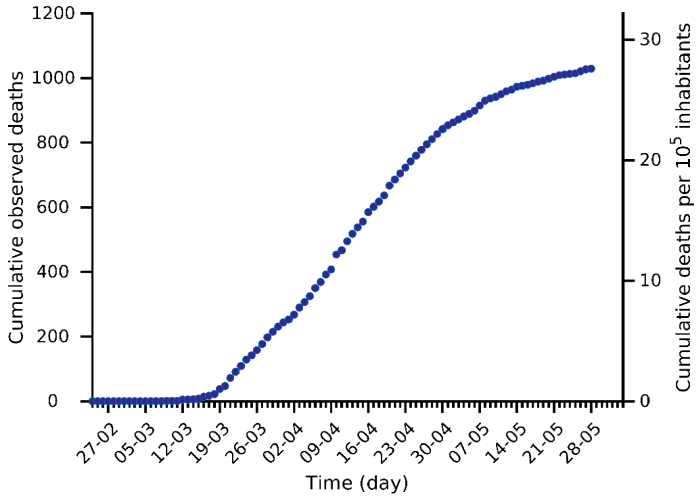


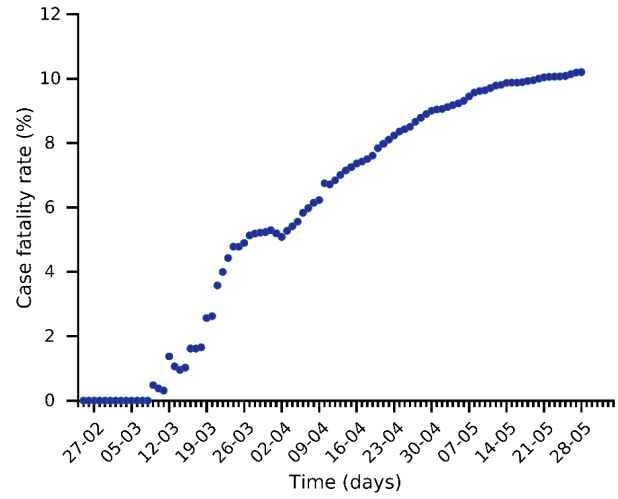




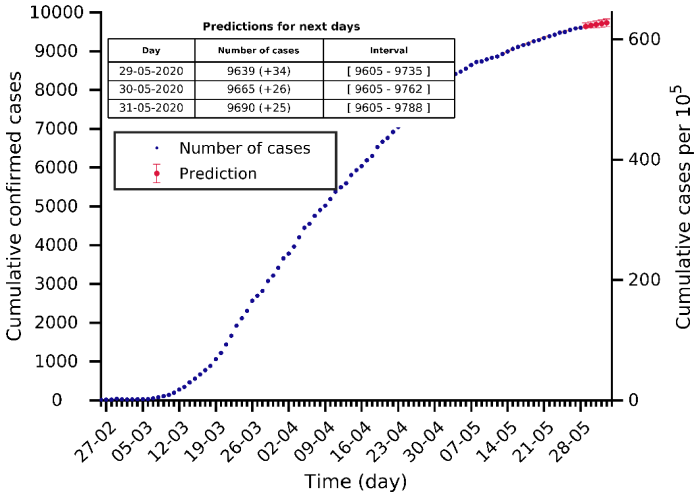


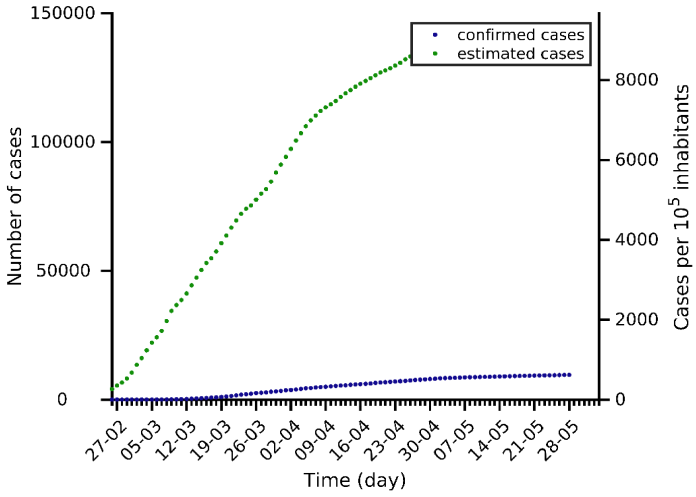


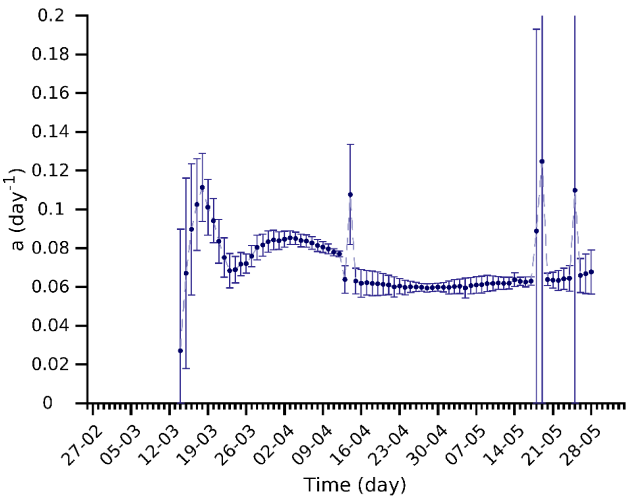


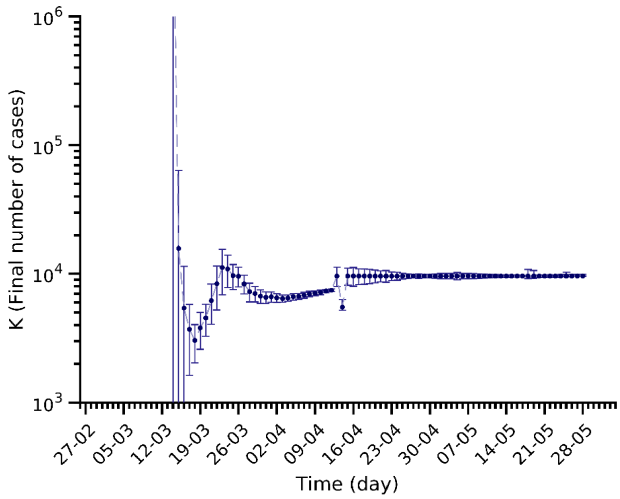


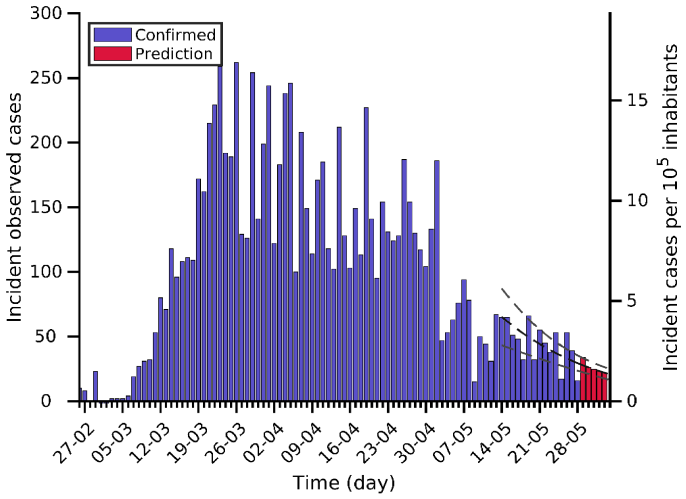
Liguria 28-05-2020. Population: 1.6M. Current cumulated incidence: 619/10⁵

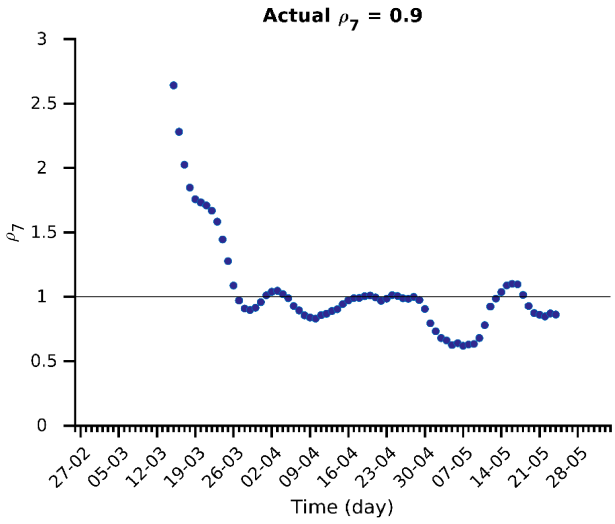


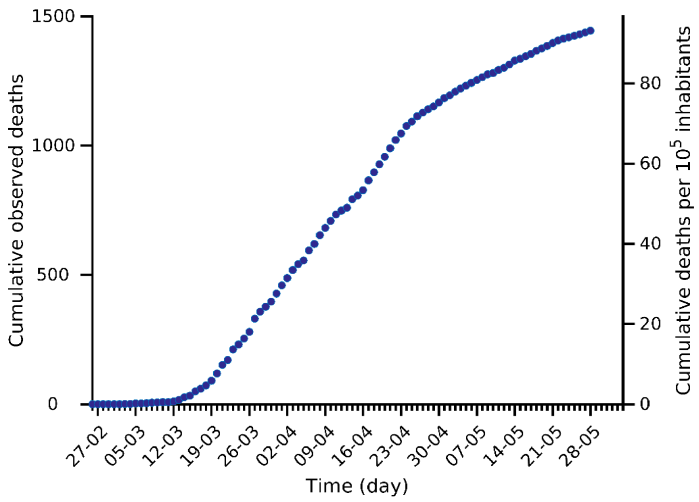


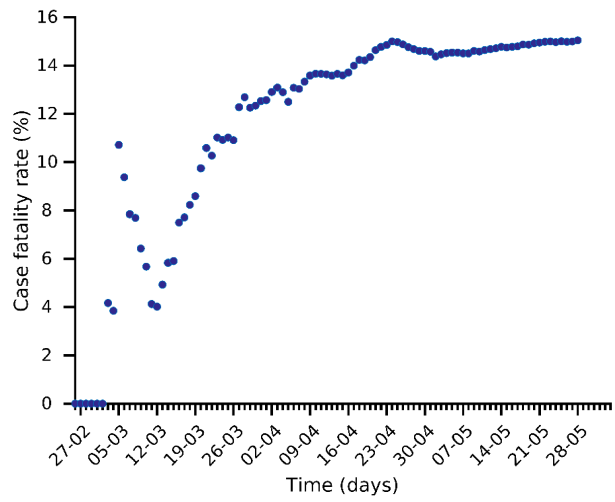




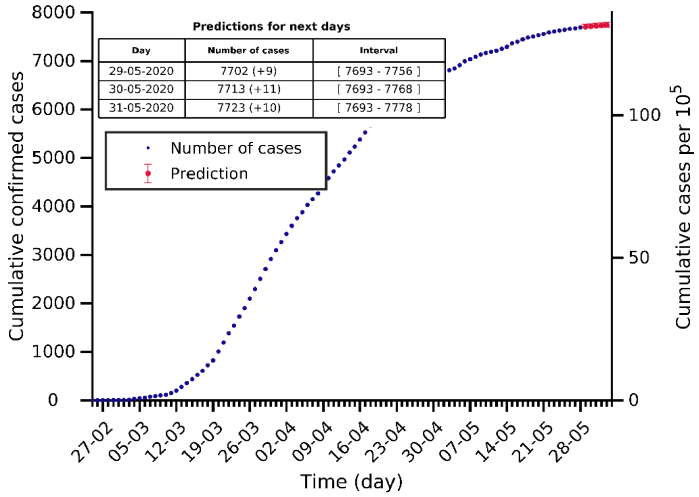


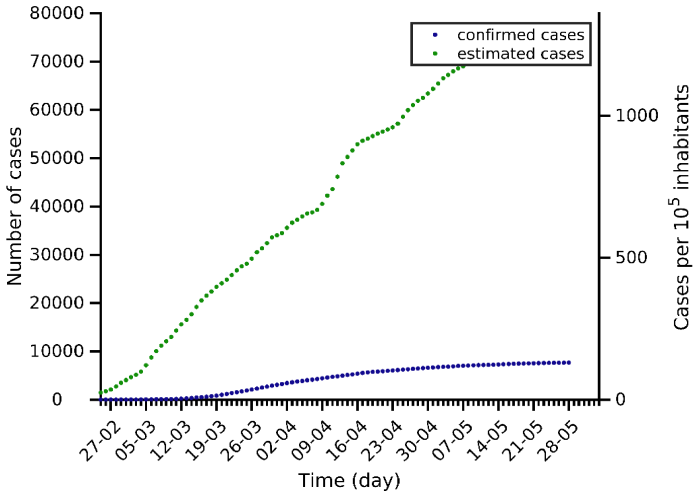


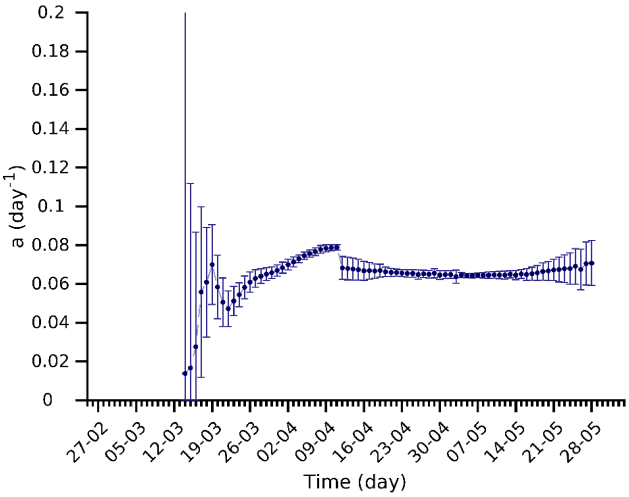


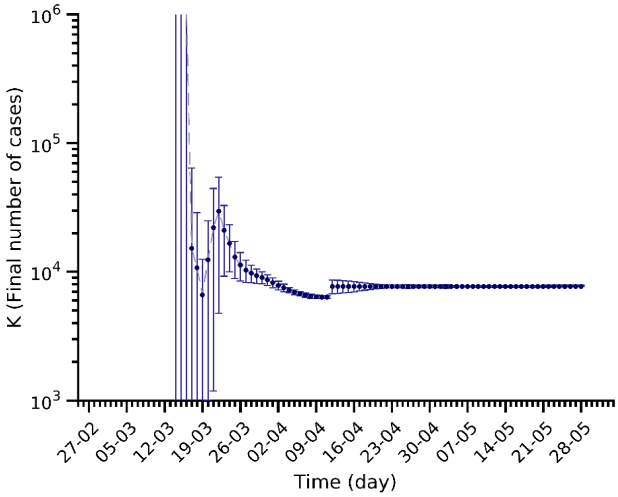


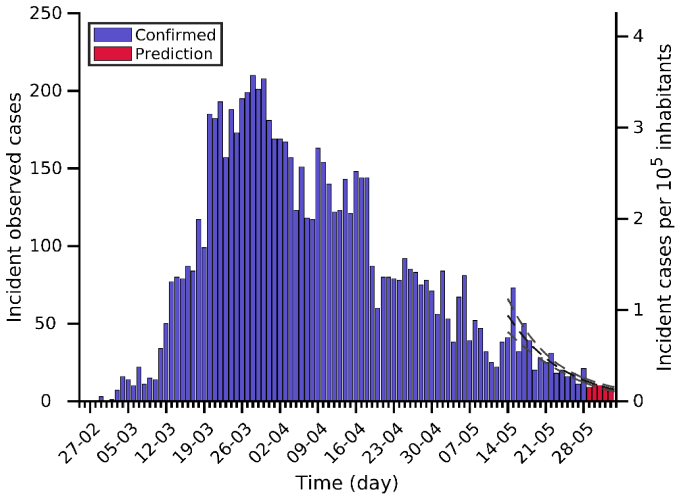
Lazio 28-05-2020. Population: 5.9M. Current cumulated incidence: 131/10^5

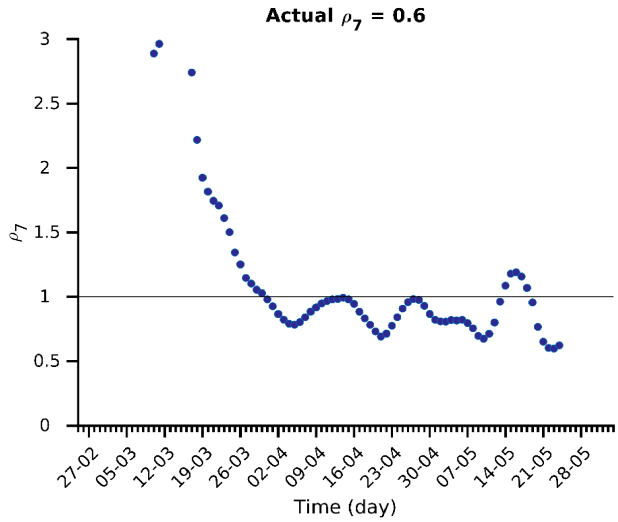


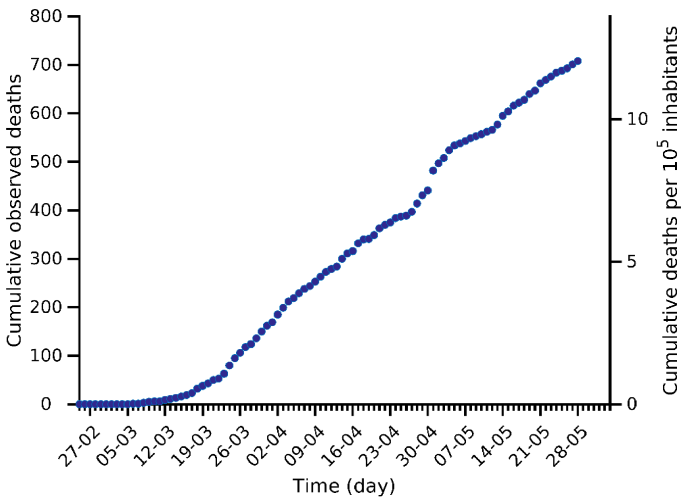


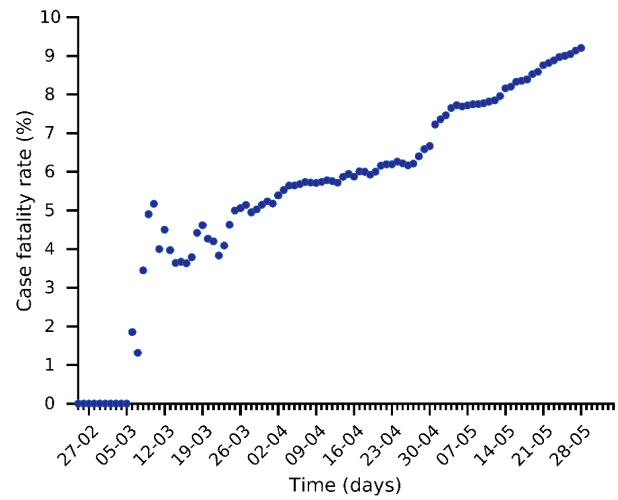




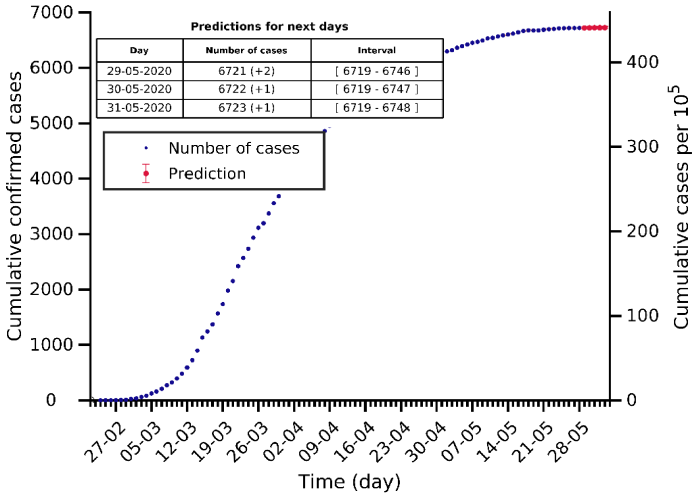


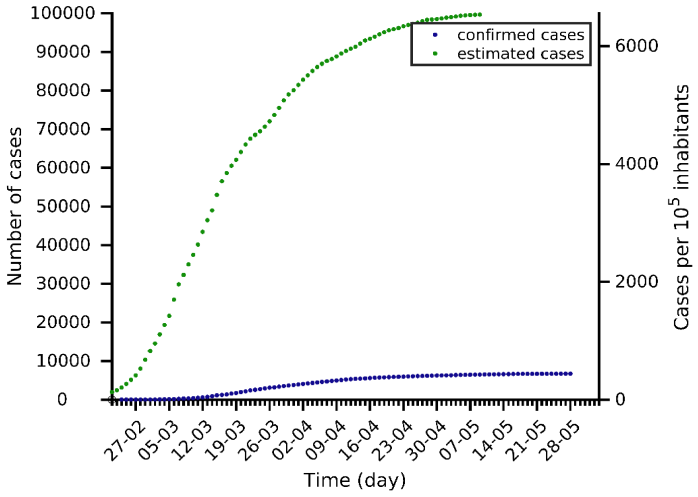


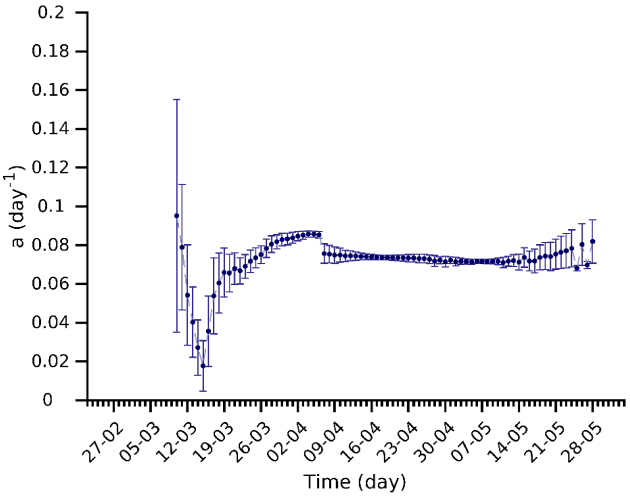


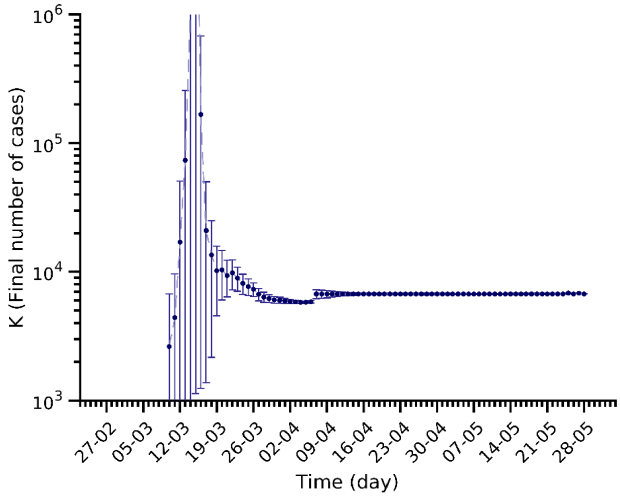


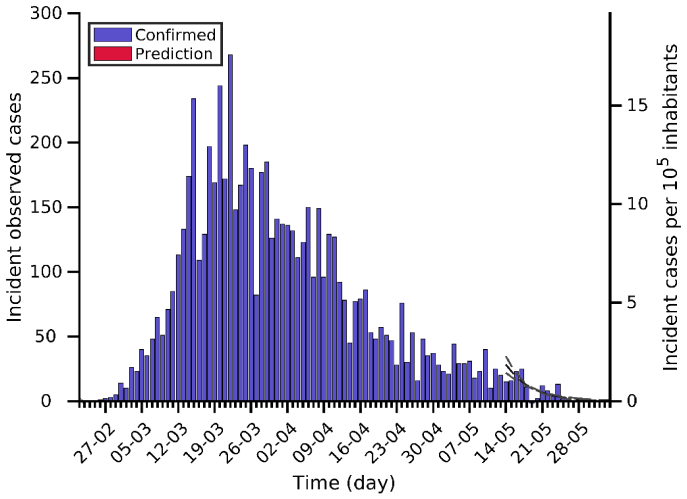
Marche 28-05-2020. Population: 1.5M. Current cumulated incidence: 441/10⁵

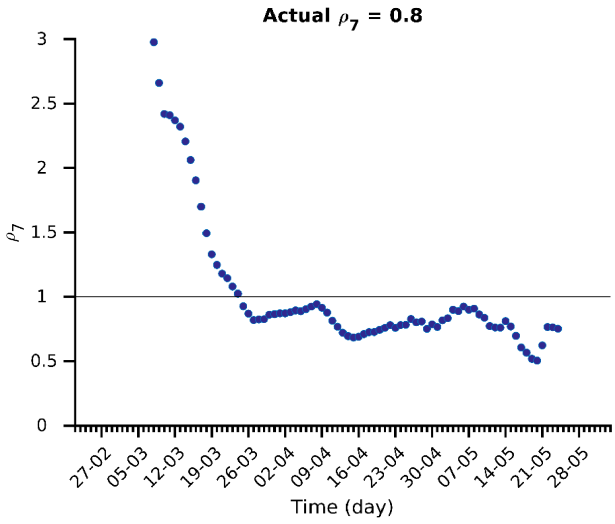


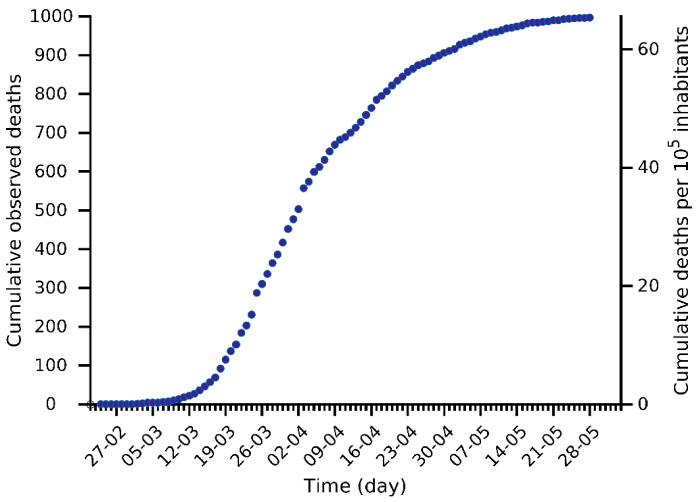


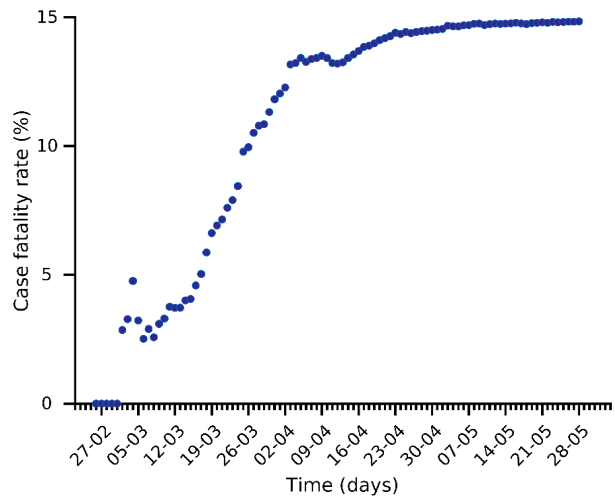




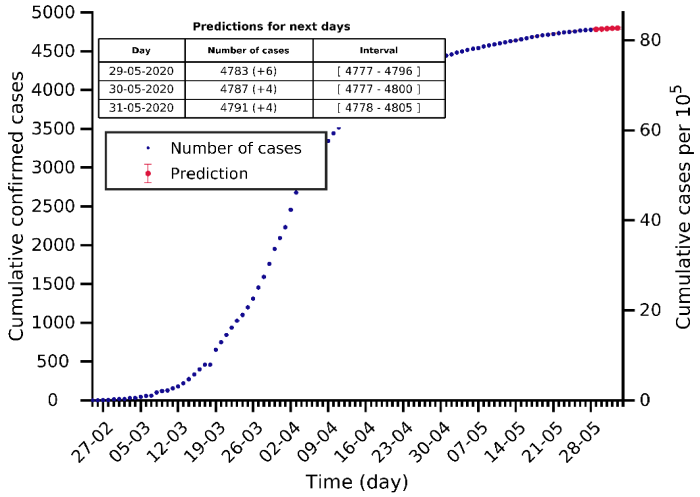


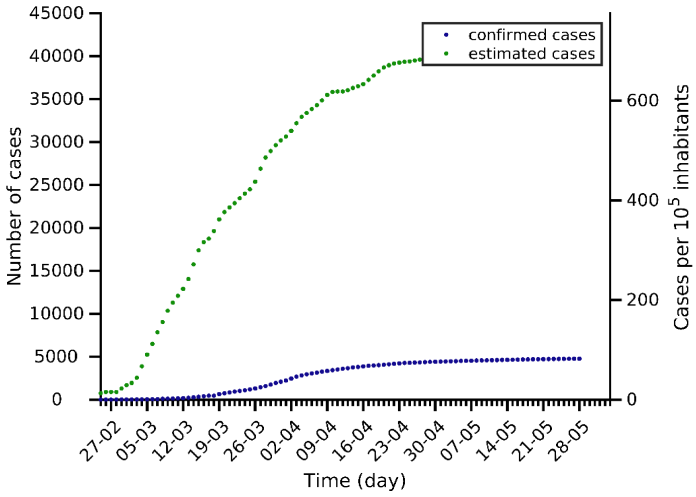


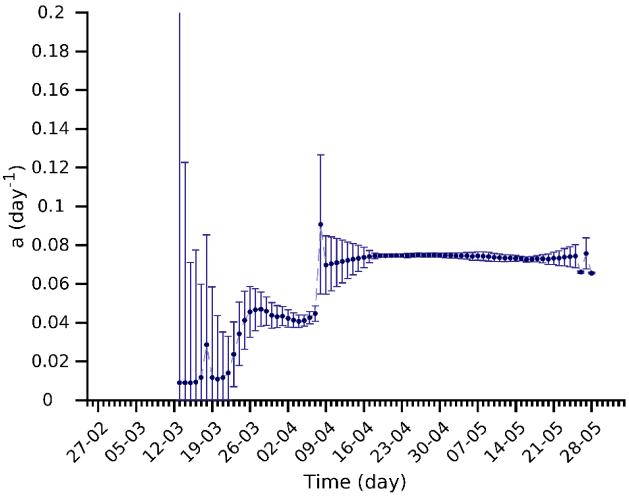


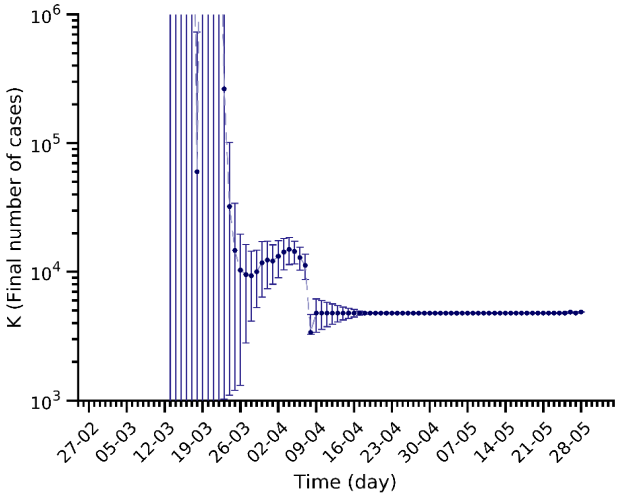


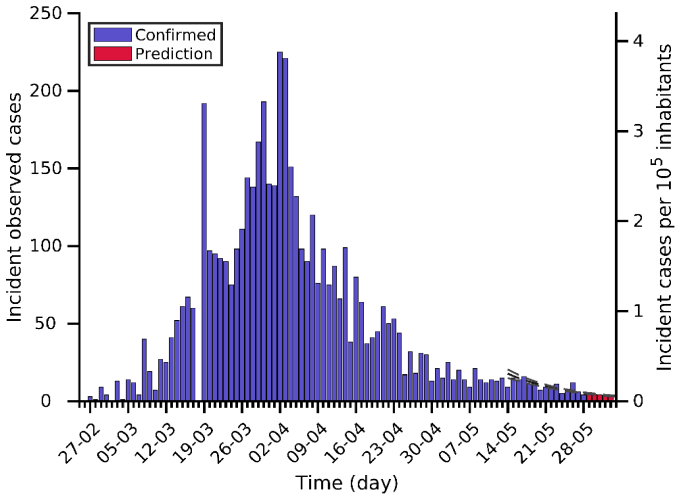
Campania 28-05-2020. Population: 5.8M. Current cumulated incidence: 82/10^5

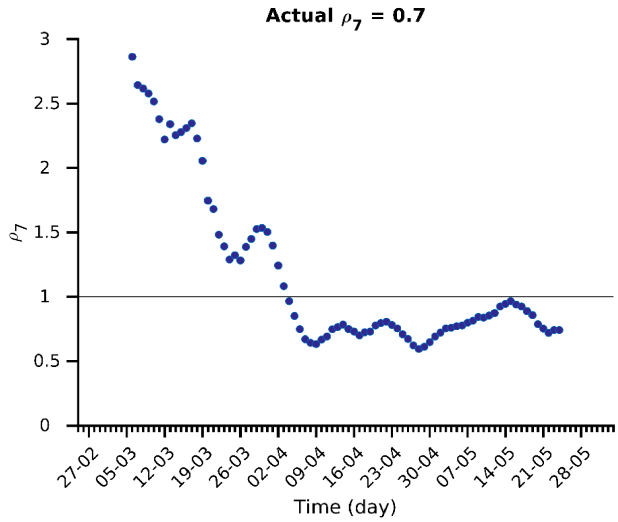


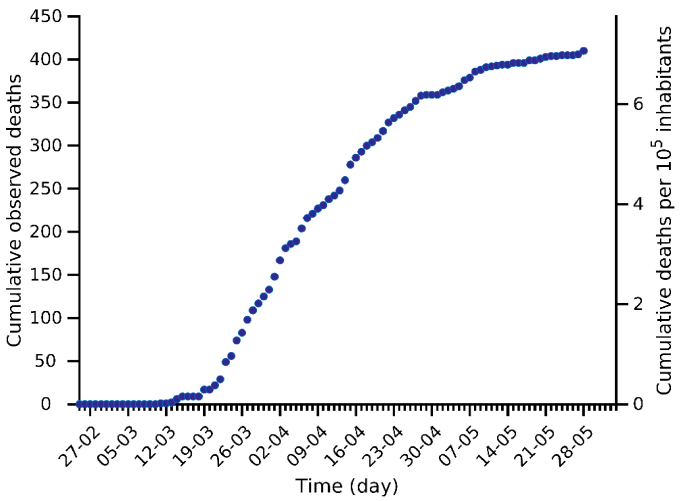


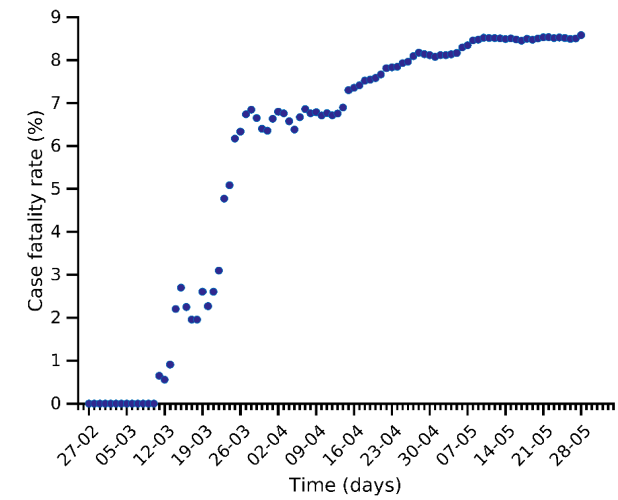




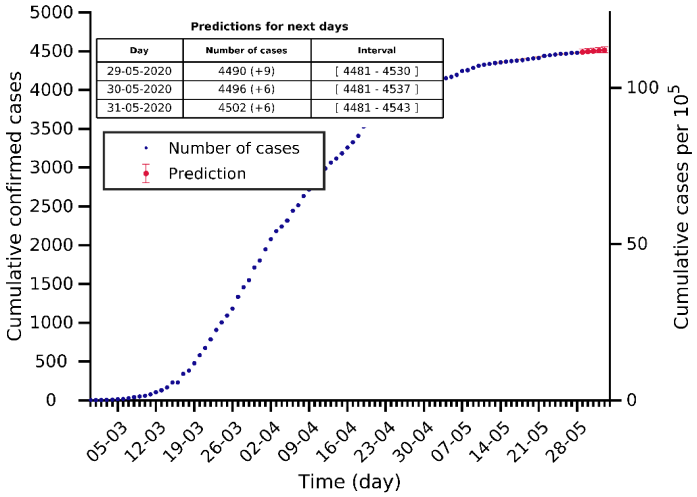


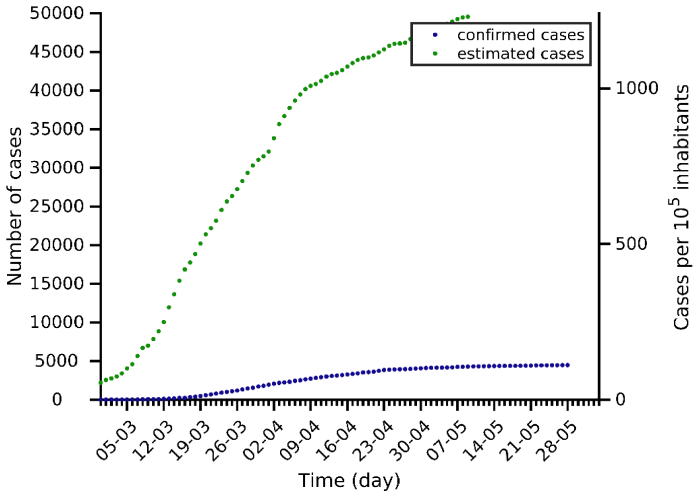


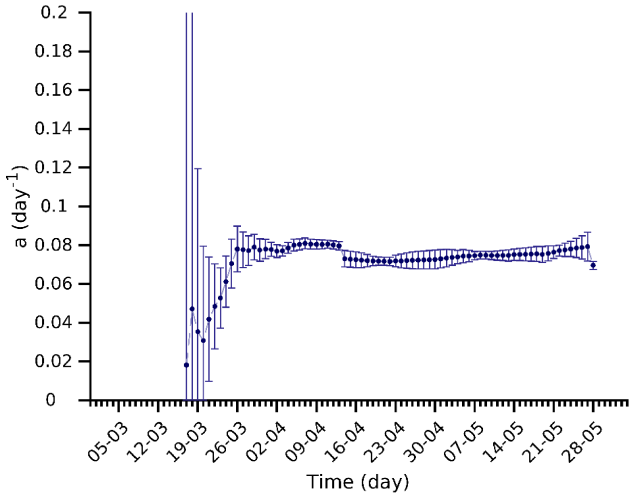


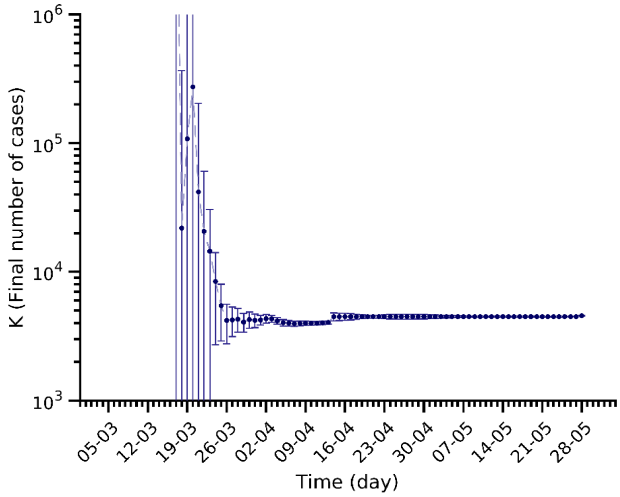


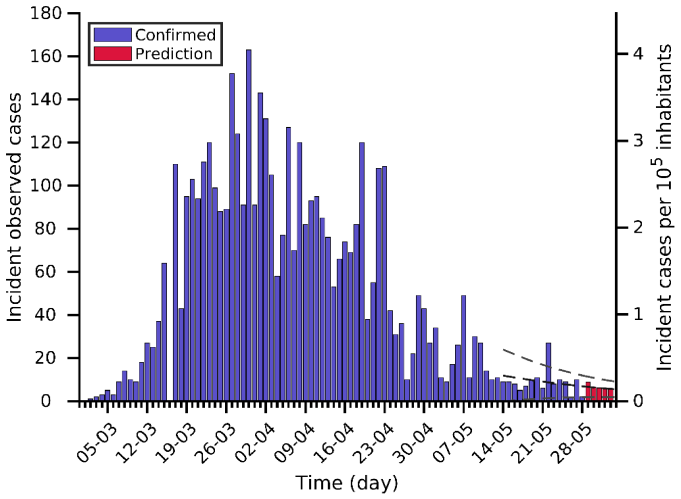
Puglia 28-05-2020. Population: 4.0M. Current cumulated incidence: 111/10^5

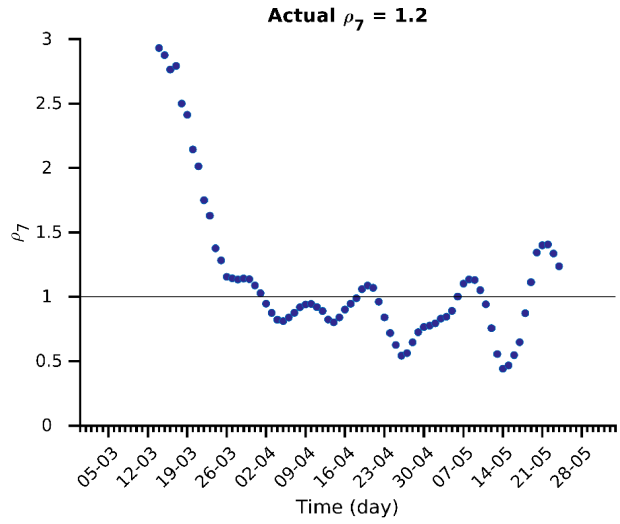


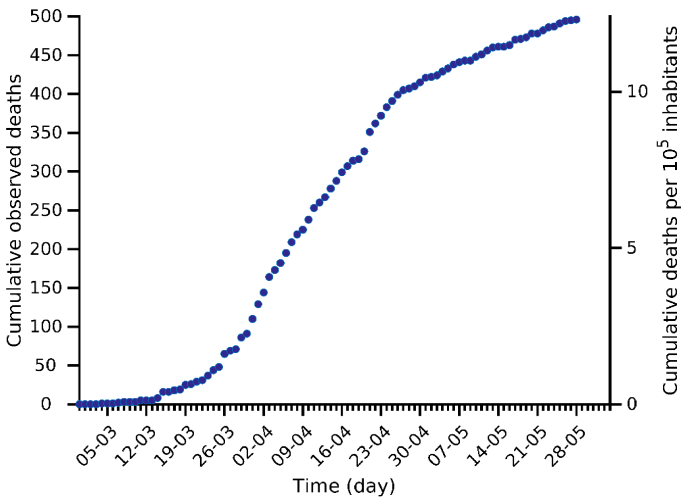


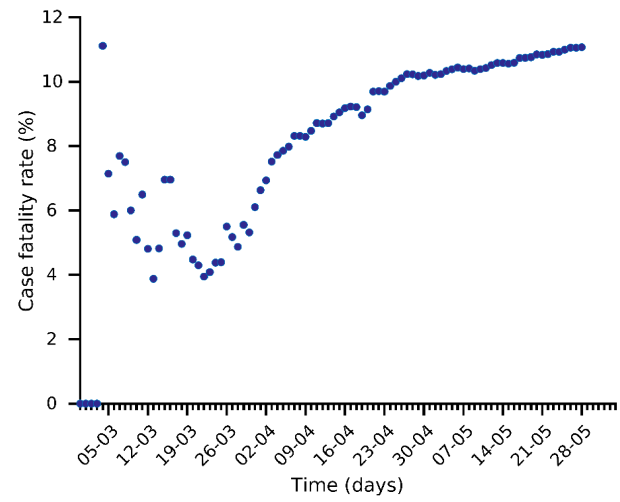




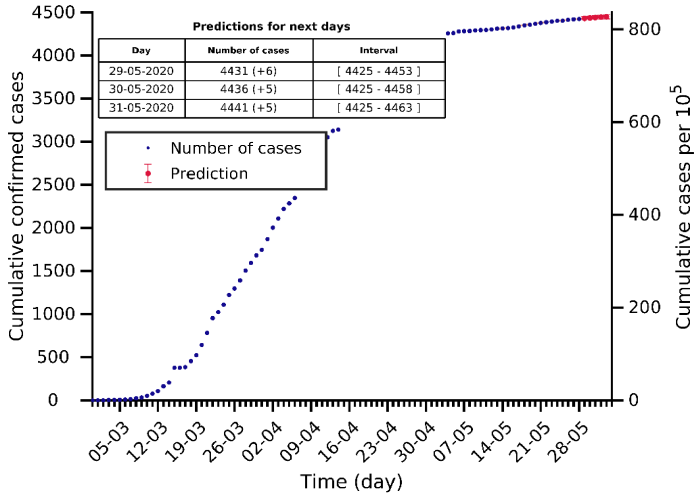


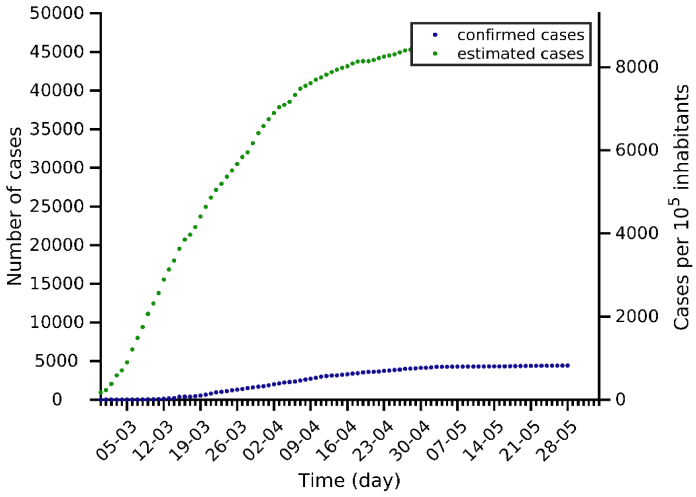


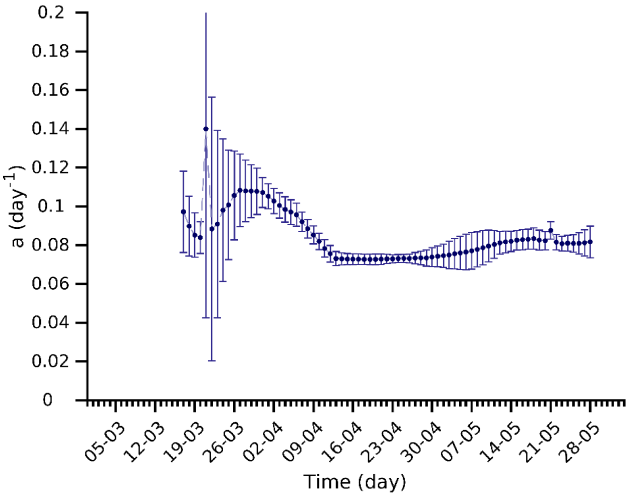


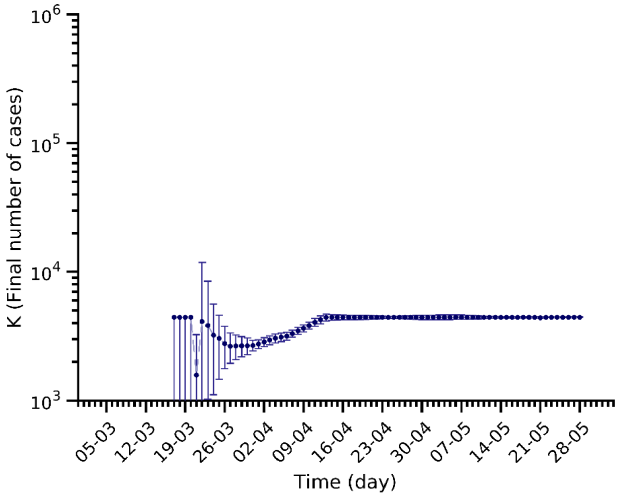


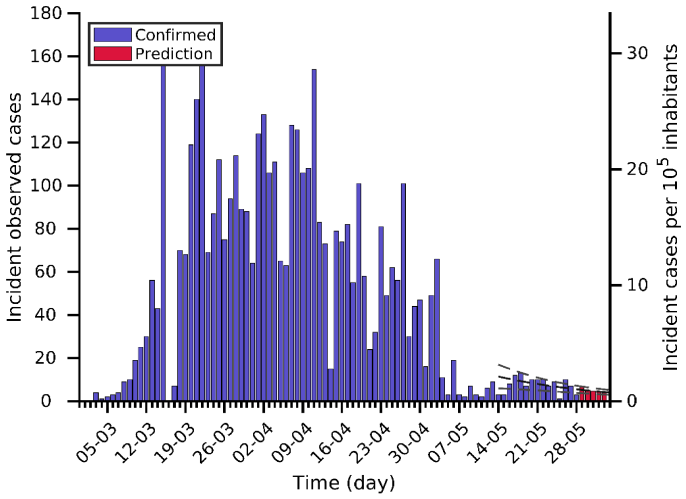
Trento 28-05-2020. Population: 0.5M. Current cumulated incidence: 822/10^5

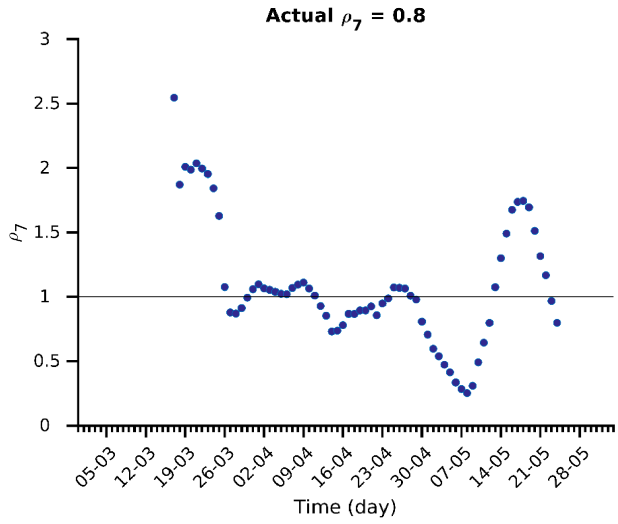


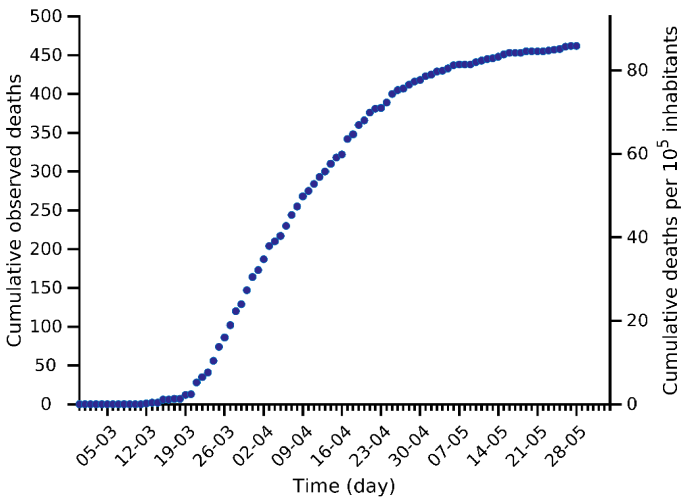


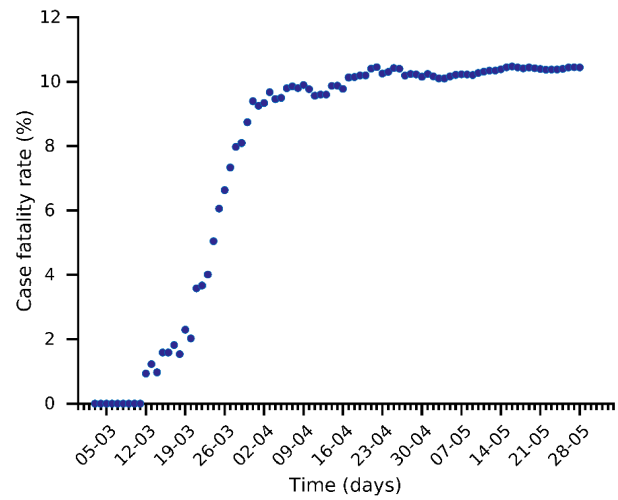




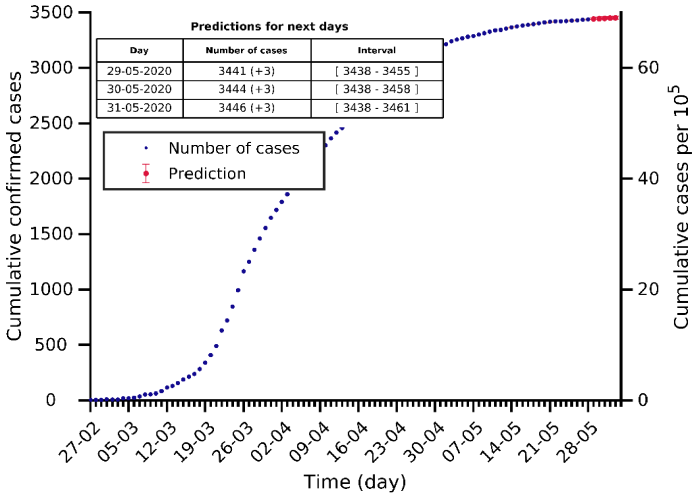


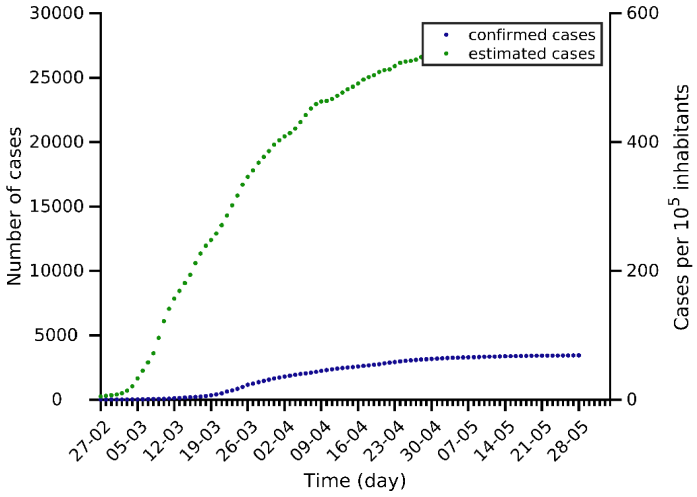


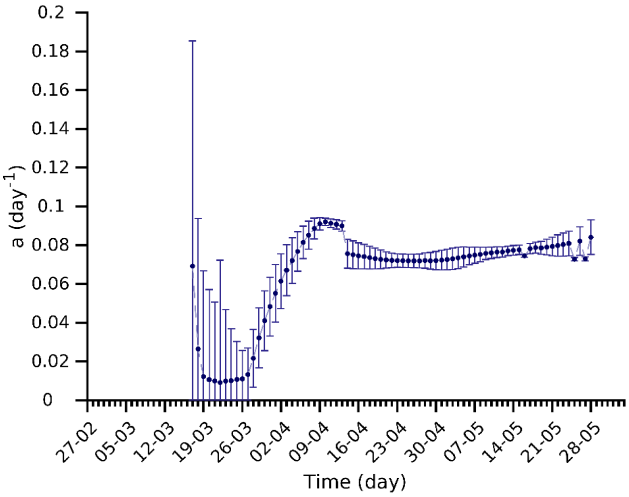


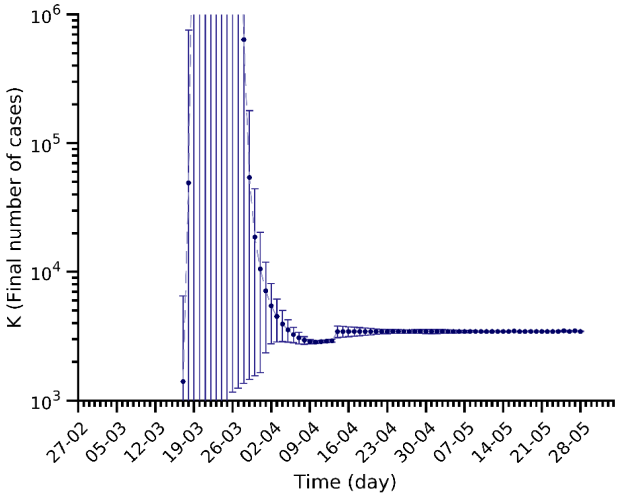


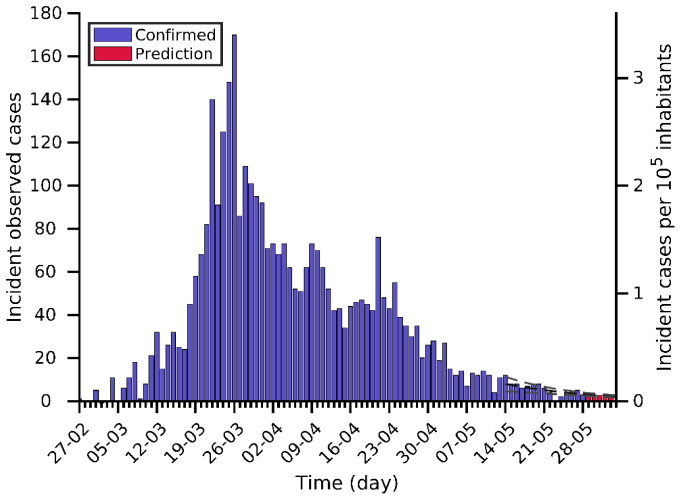
Sicilia 28-05-2020. Population: 5.0M. Current cumulated incidence: 69/10⁵

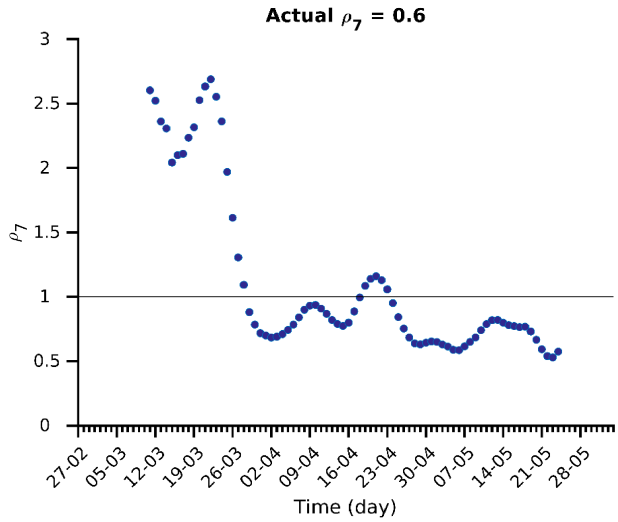


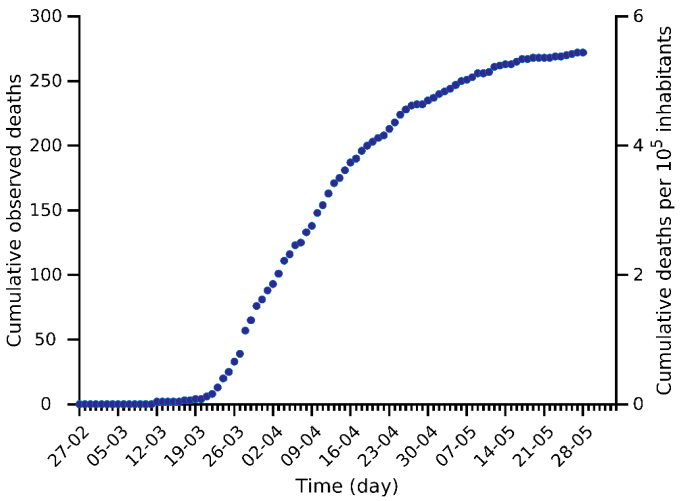


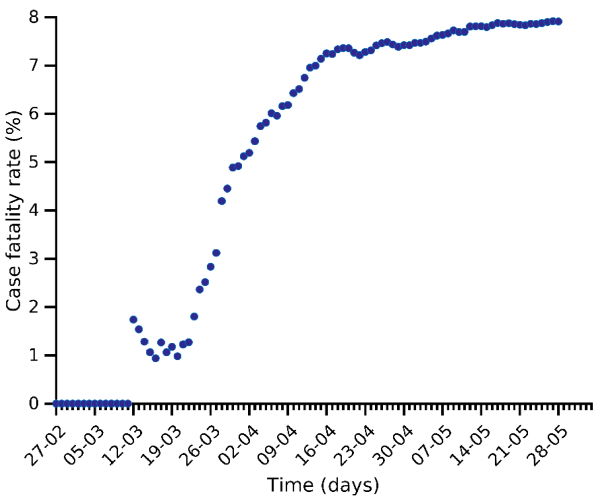




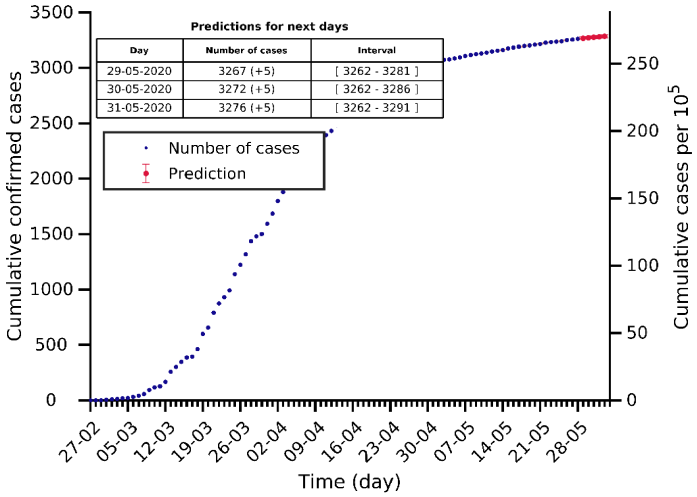


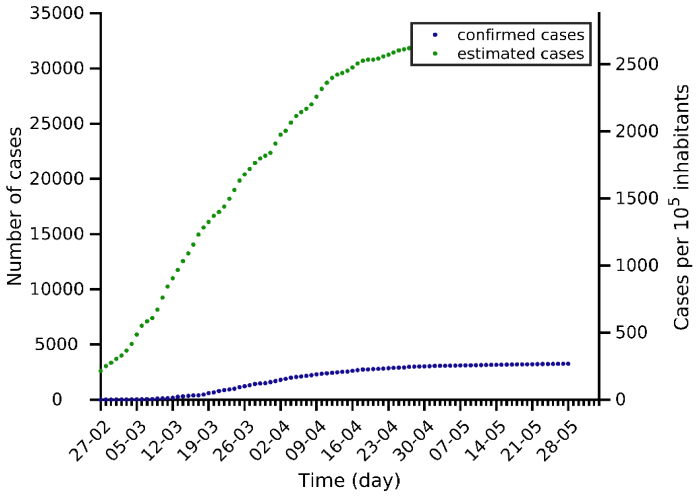


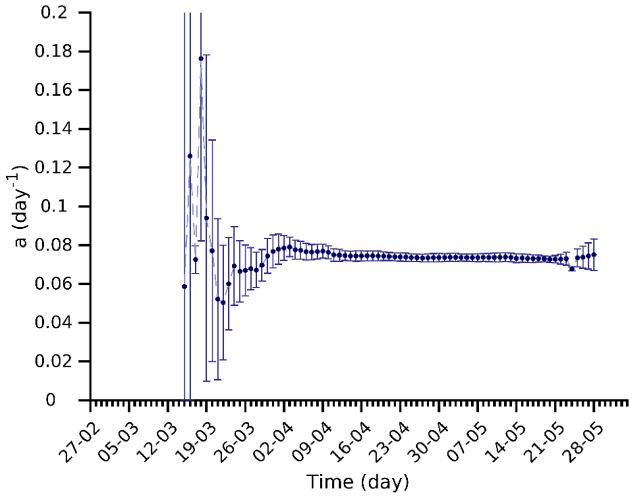


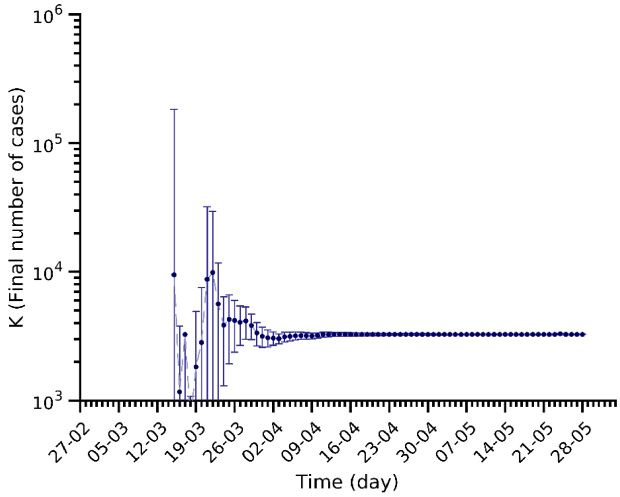


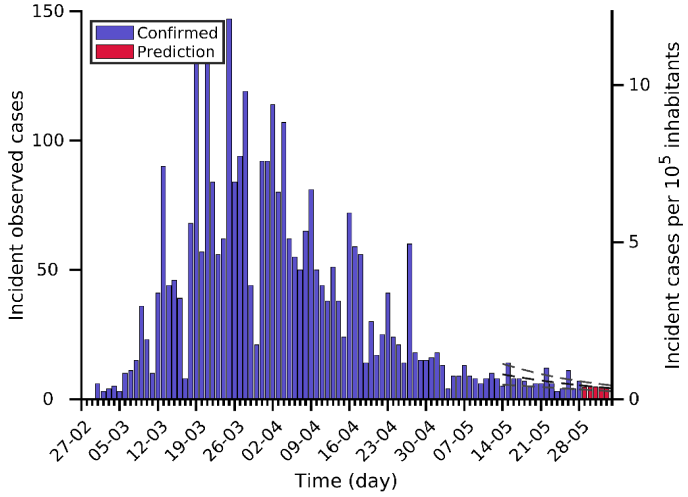
Friuli Venezia Giulia 28-05-2020. Population: 1.2M. Current cumulated incidence: 2

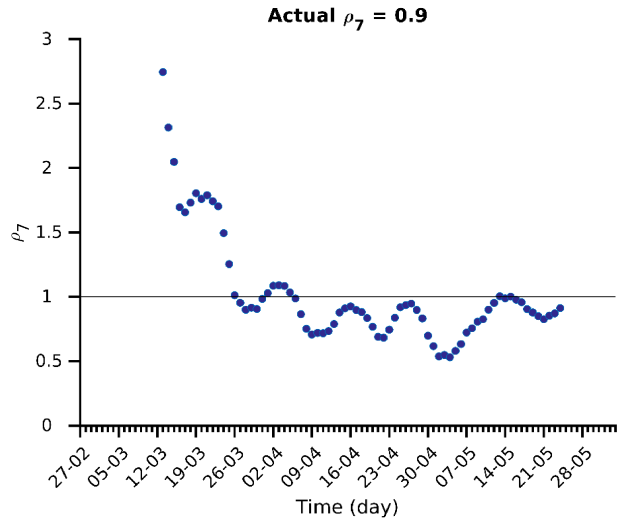


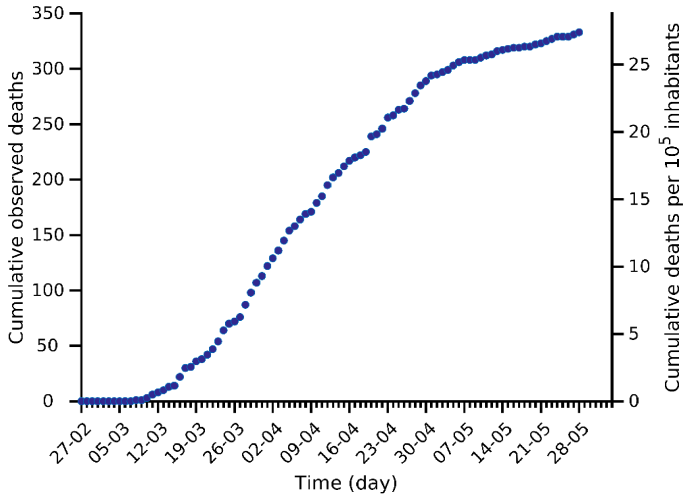


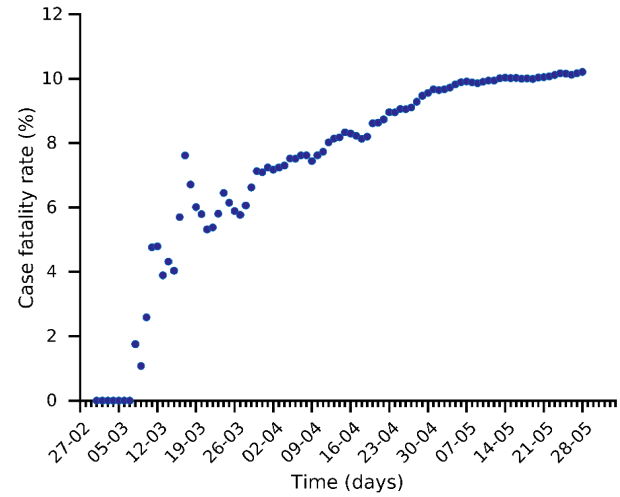




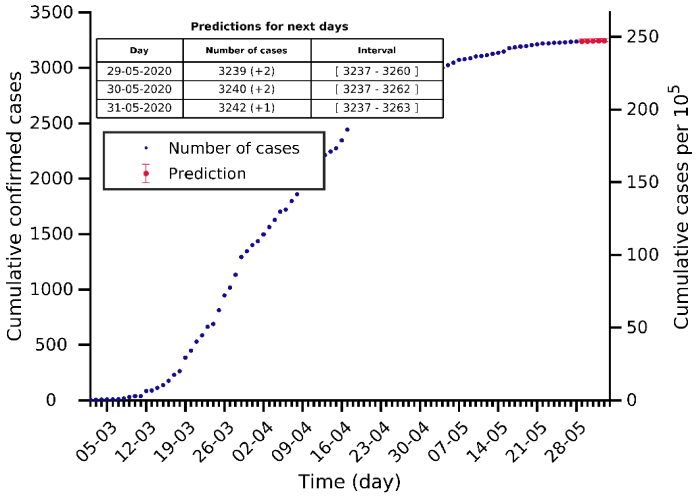


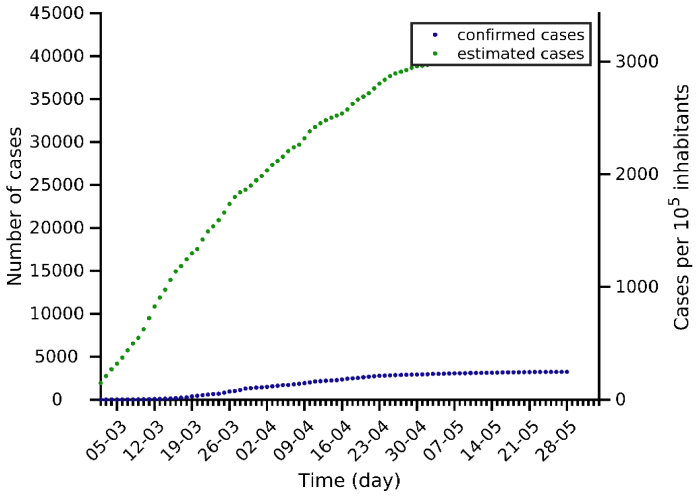


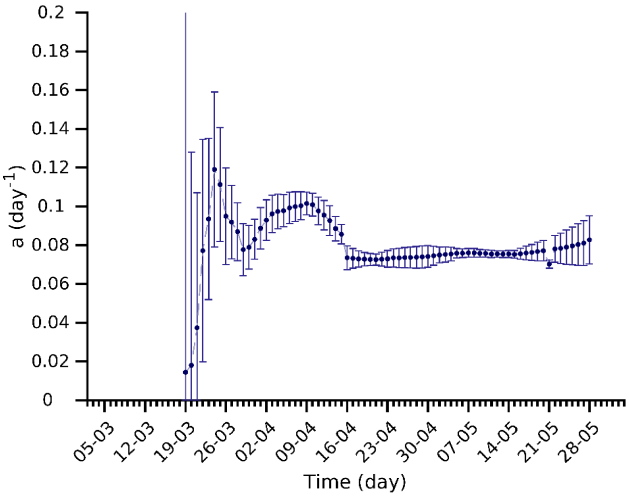


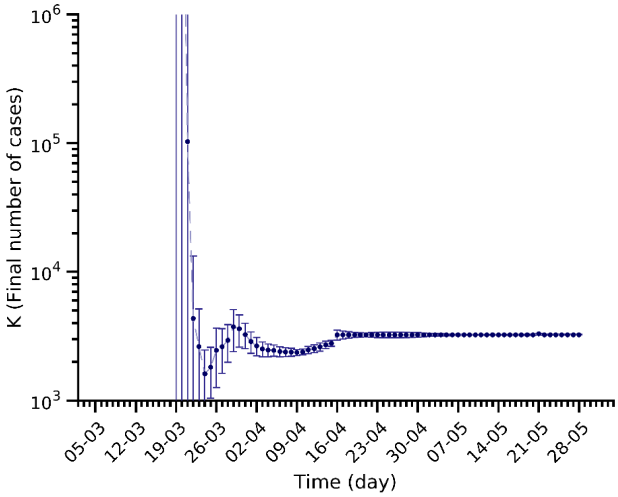


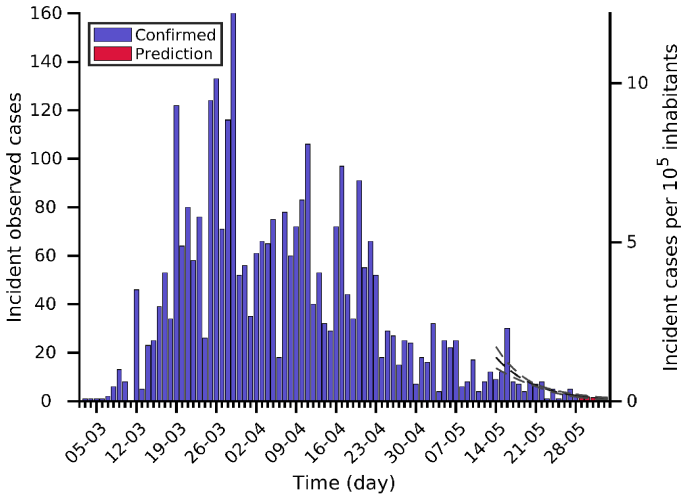
Abruzzo 28-05-2020. Population: 1.3M. Current cumulated incidence: 247/10^5

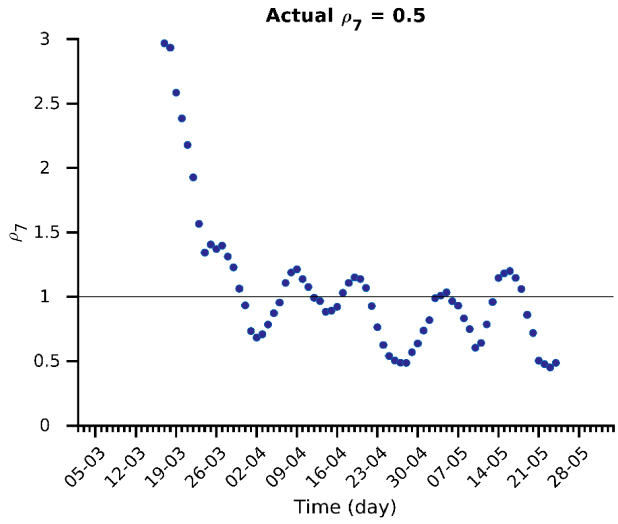


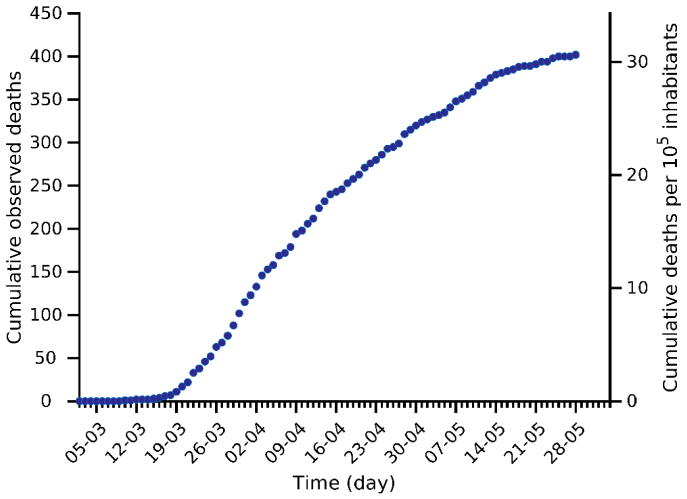


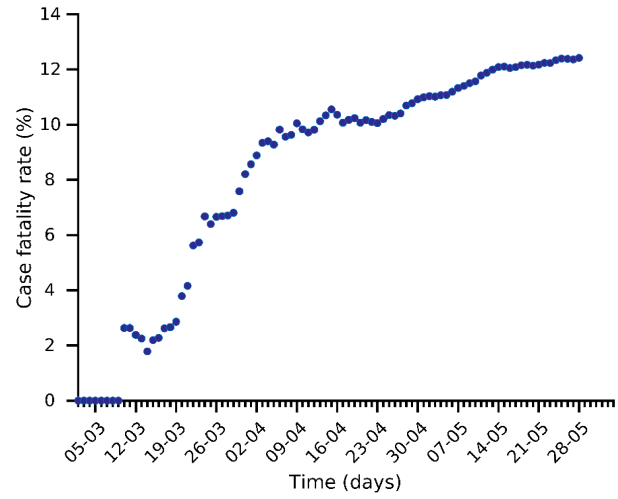




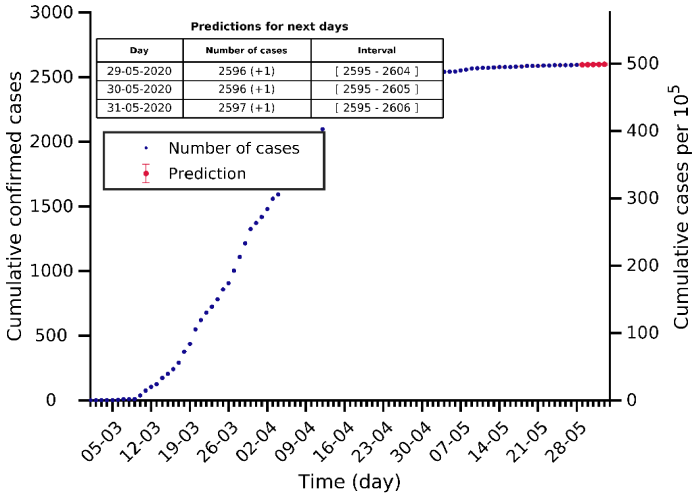


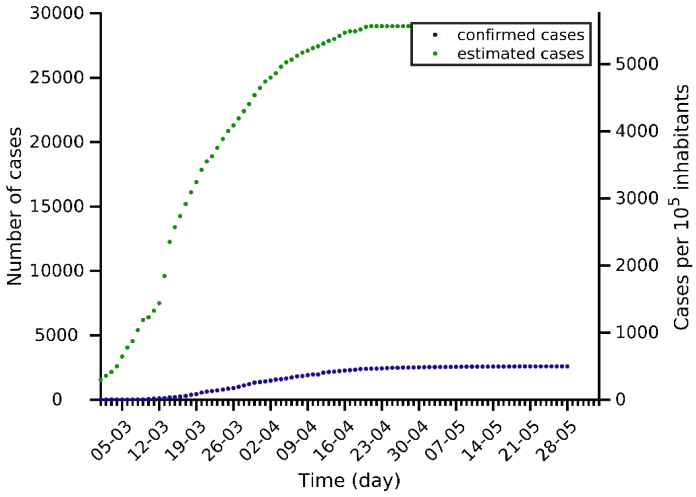


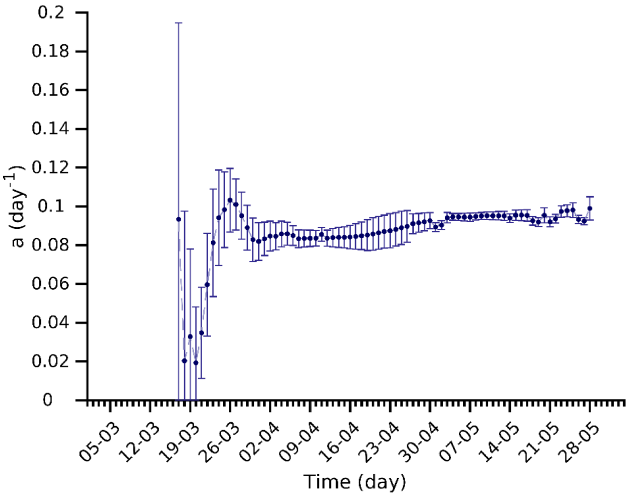


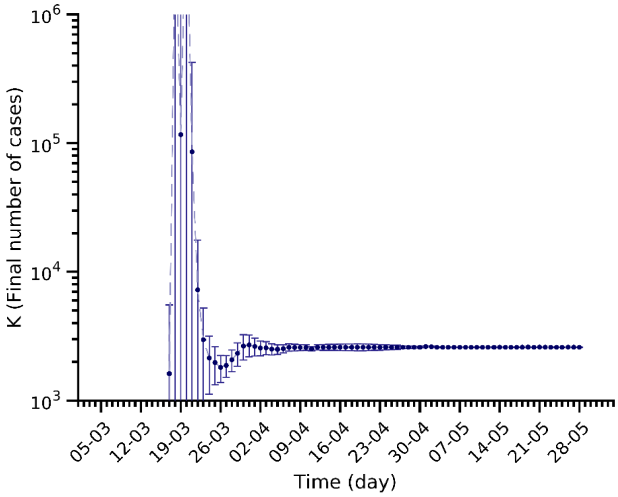


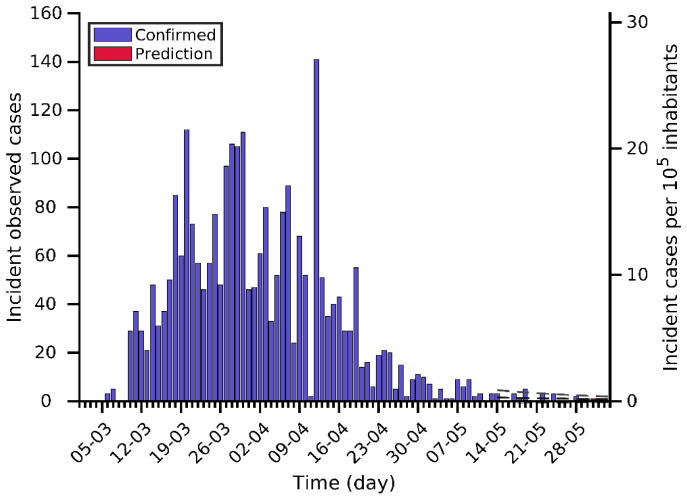
Bolzano 28-05-2020. Population: 0.5M. Current cumulated incidence: 498/10^5

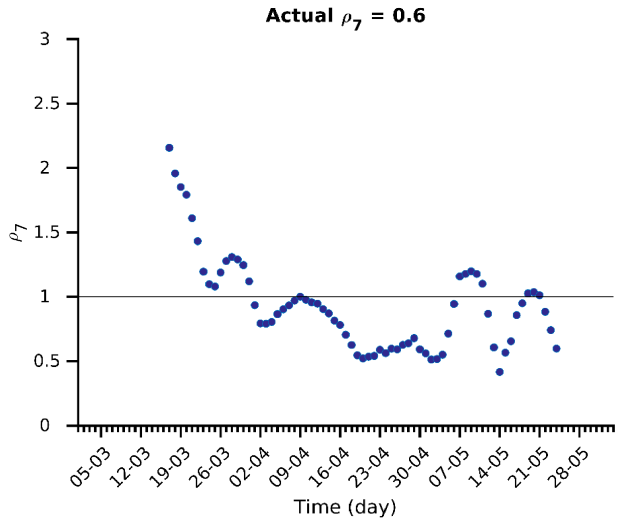


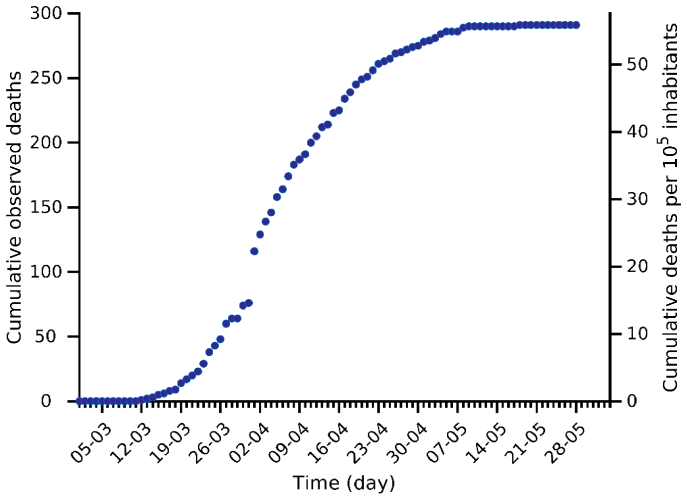


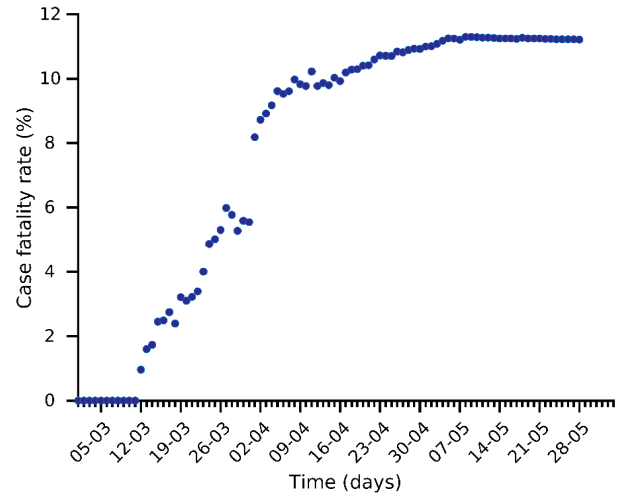




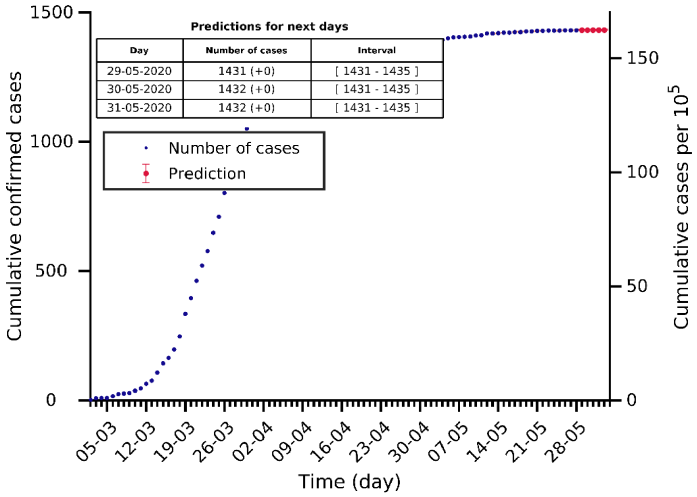


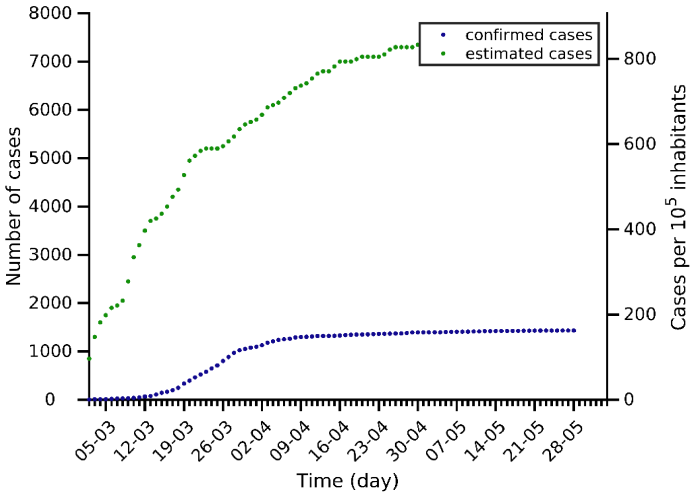


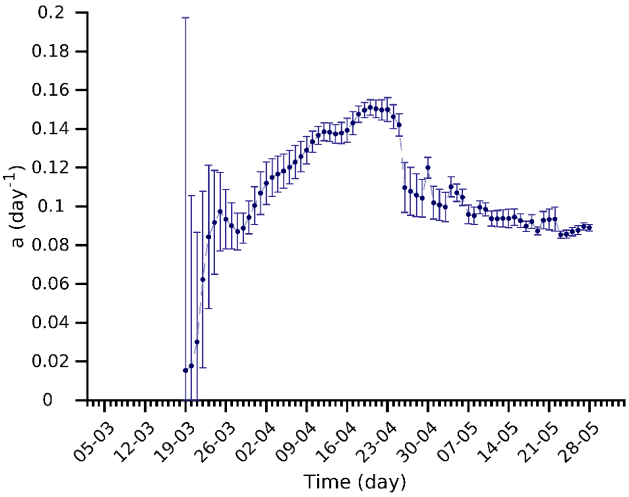


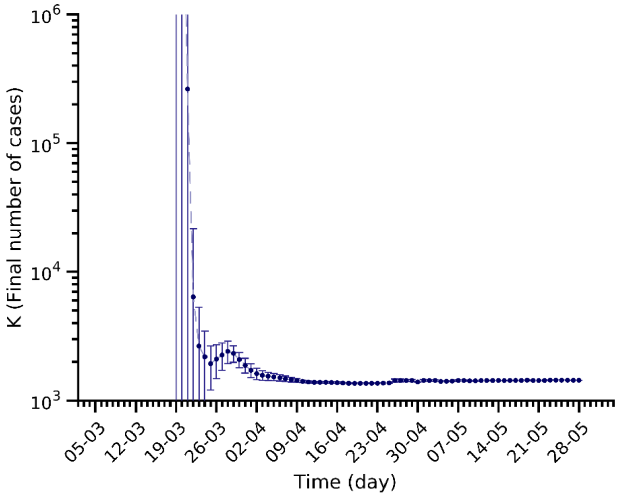


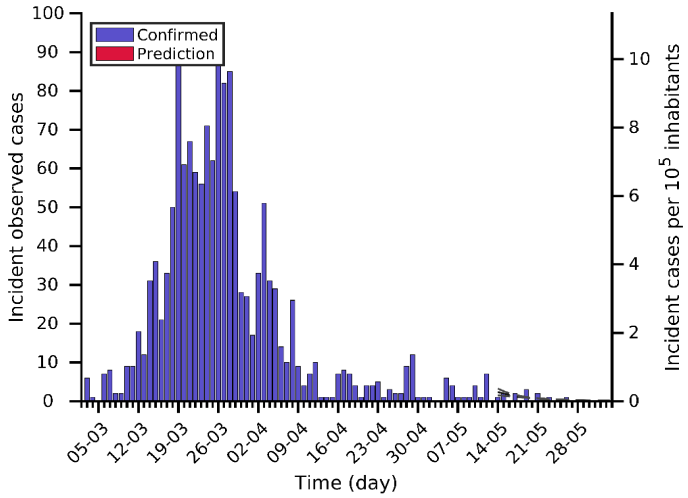
Umbria 28-05-2020. Population: 0.9M. Current cumulated incidence: $162/10^5$

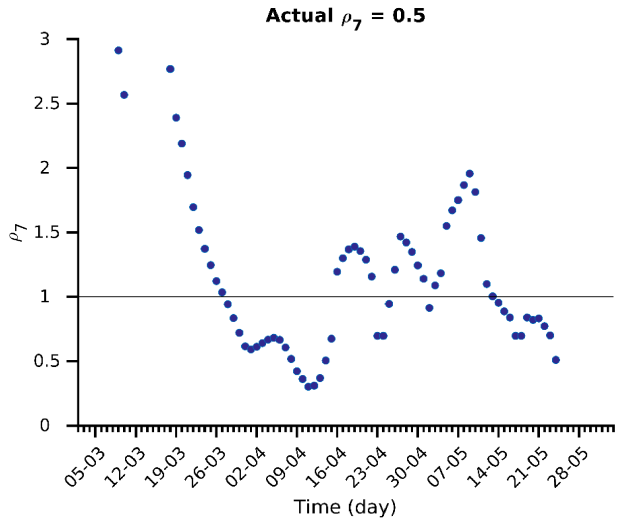


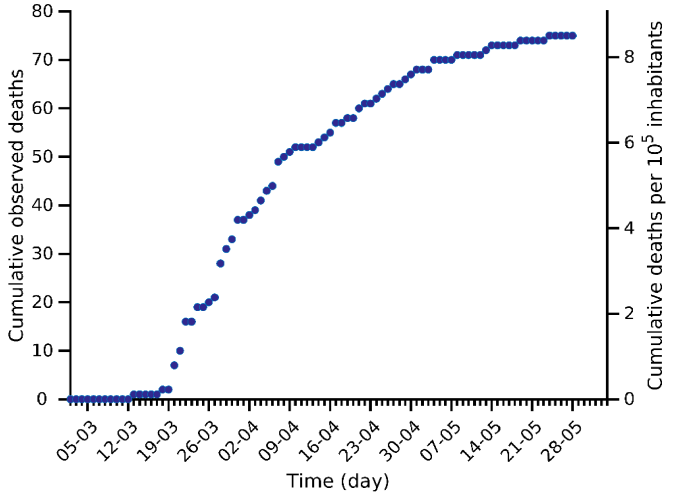


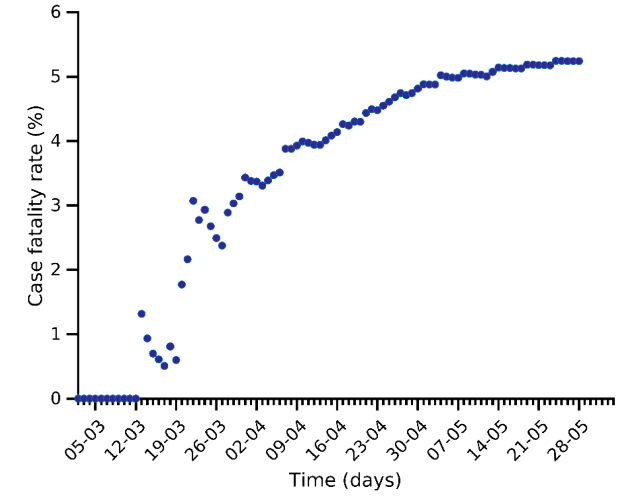




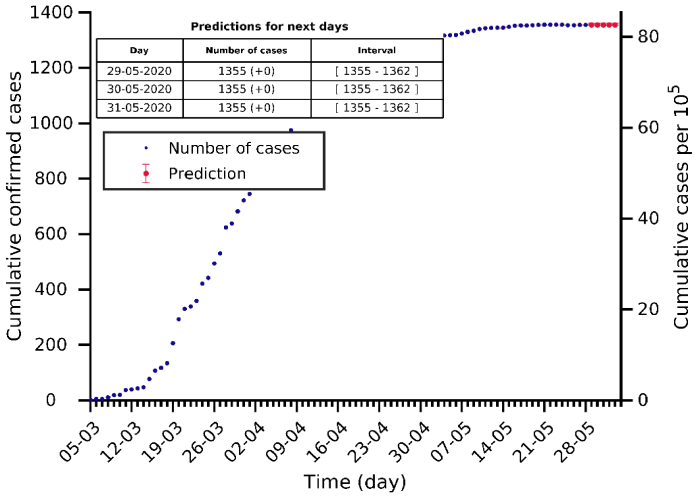


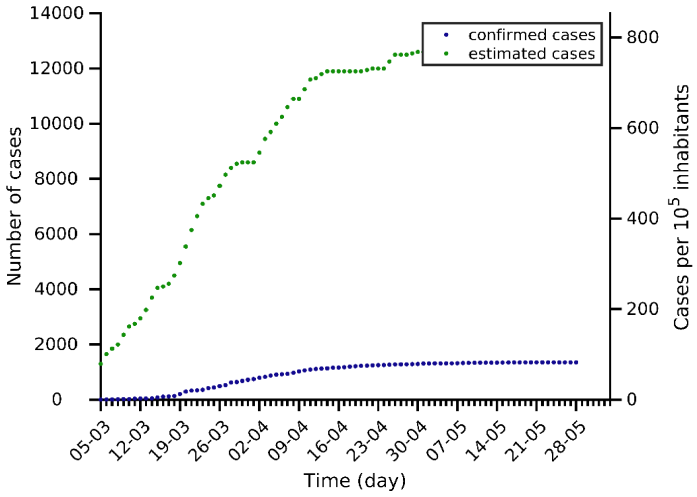


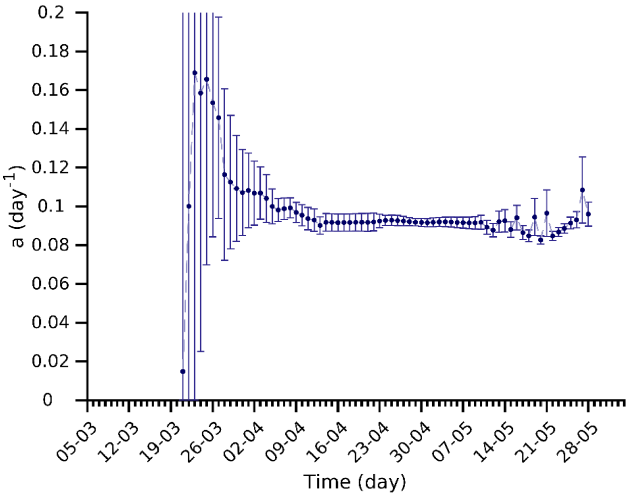


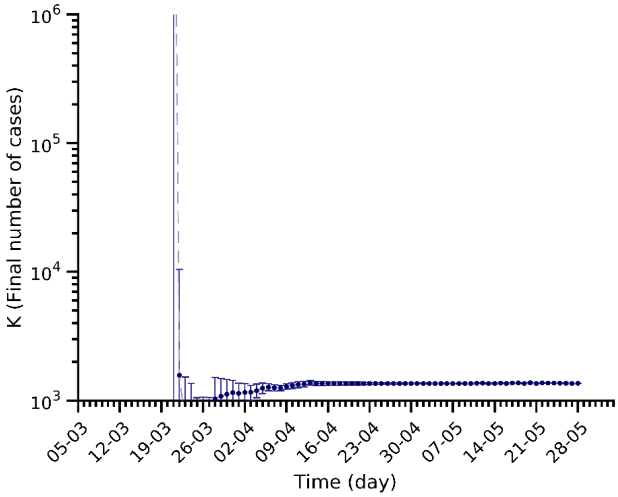


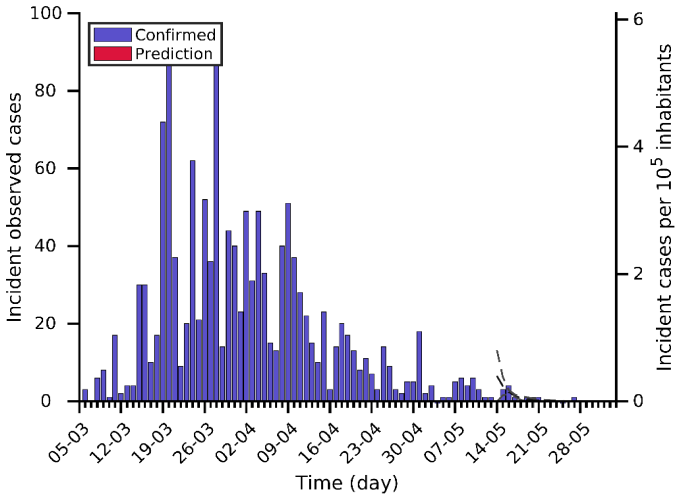
Sardegna 28-05-2020. Population: 1.6M. Current cumulated incidence: 83/10⁵

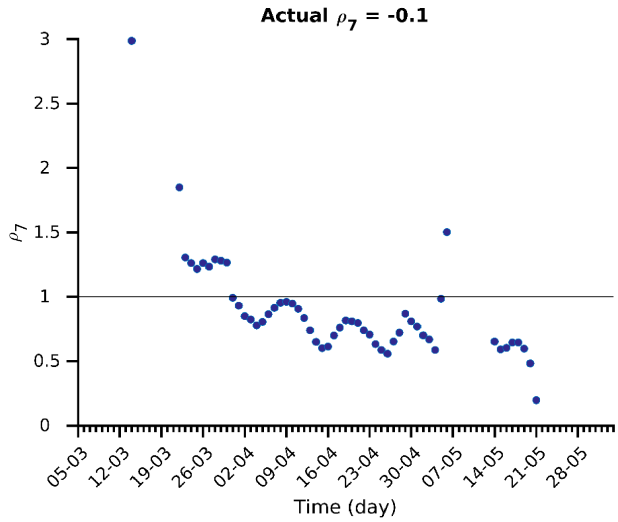


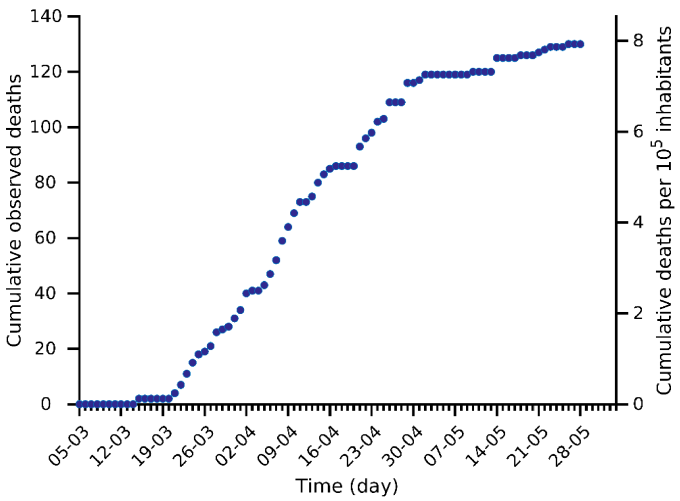


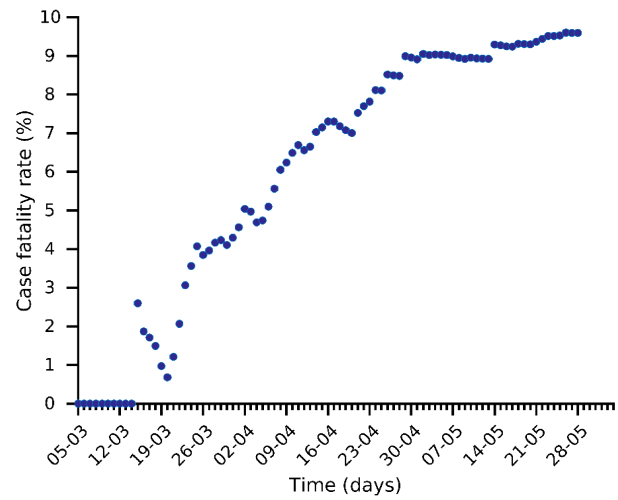




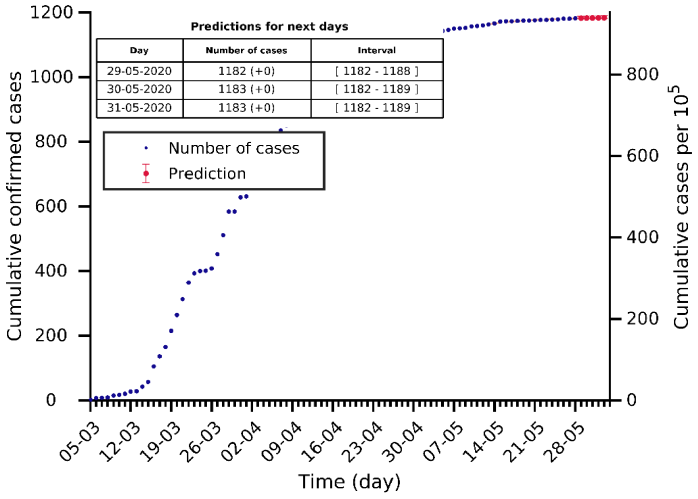


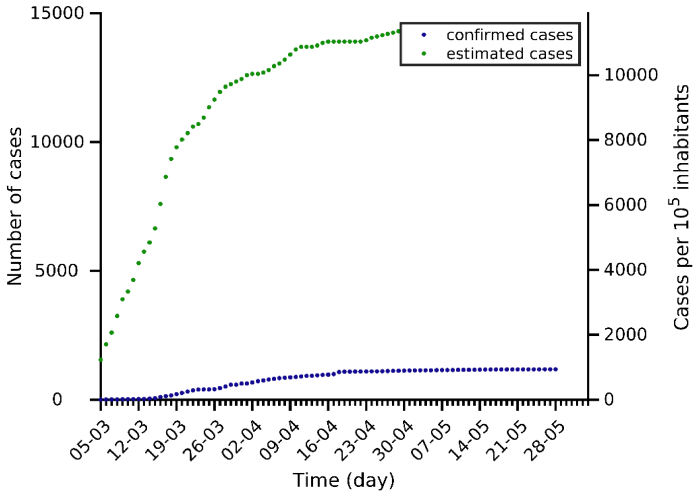


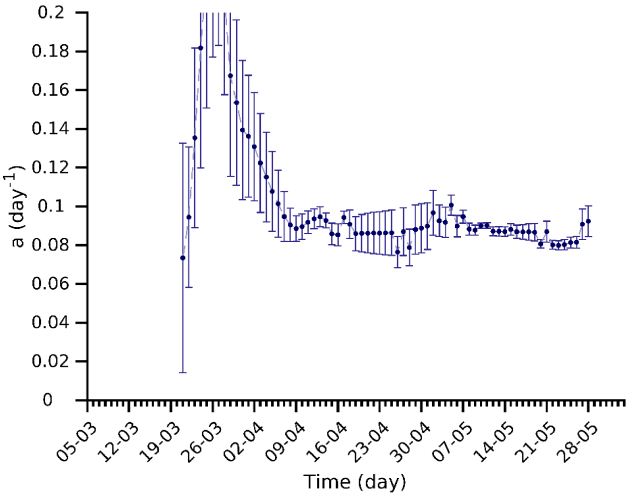


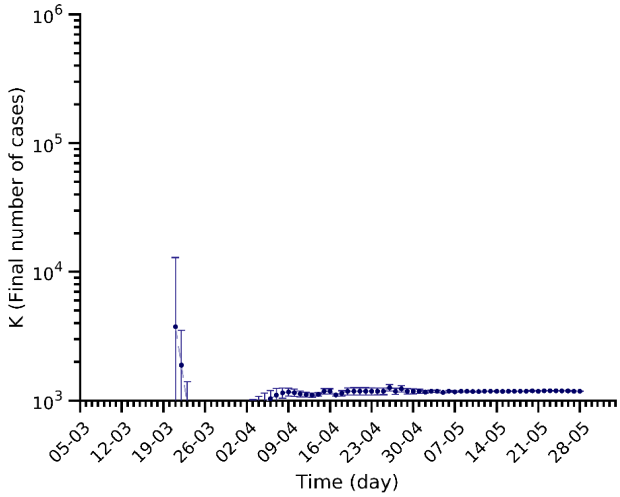


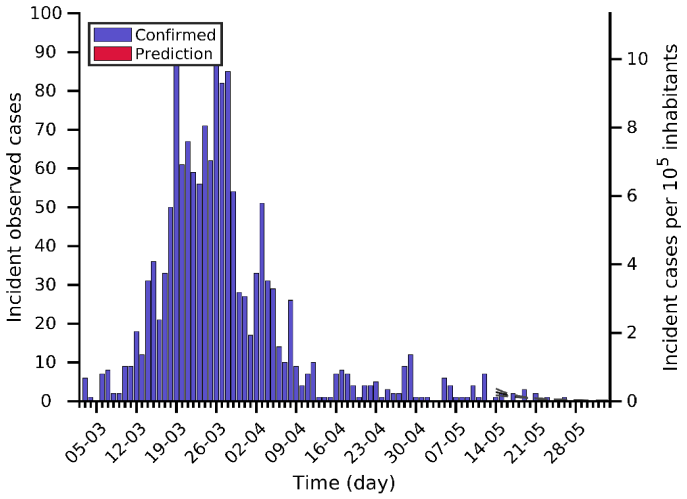
Valle dAosta 28-05-2020. Population: 0.1M. Current cumulated incidence: 938/10^5

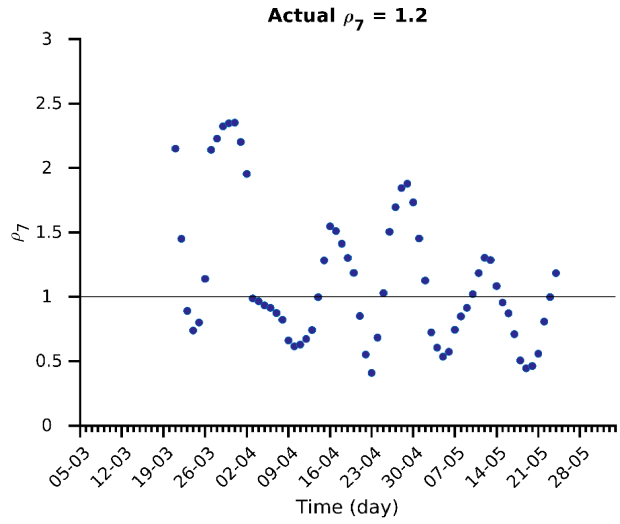


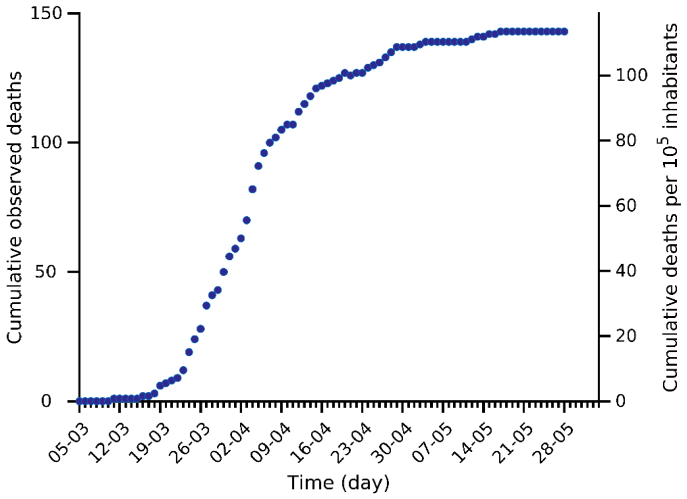


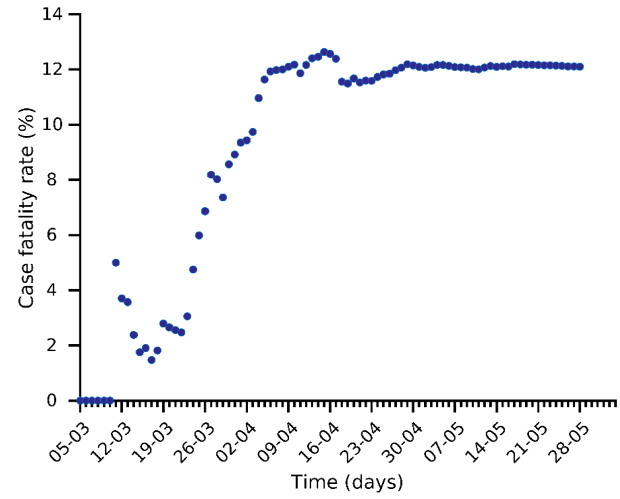




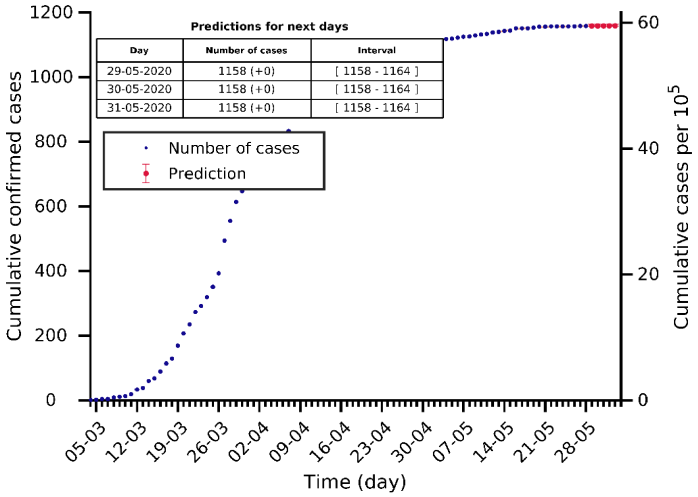


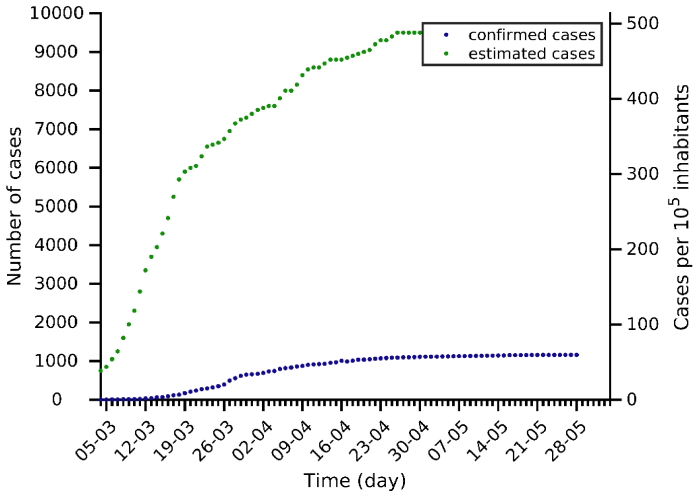


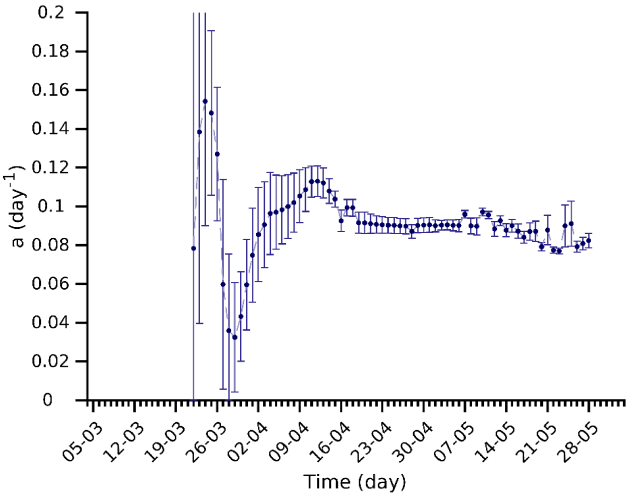


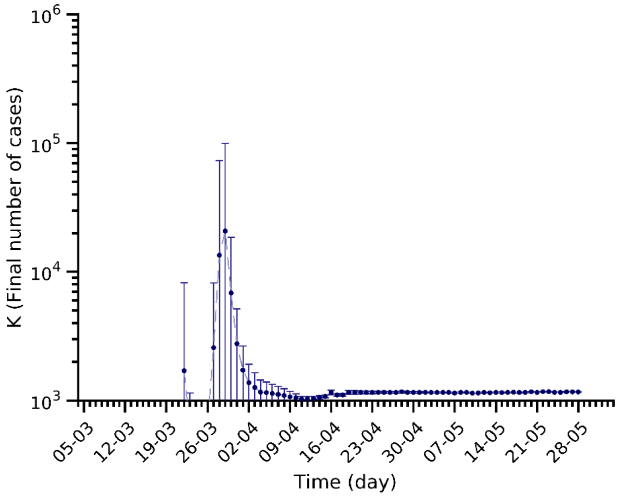


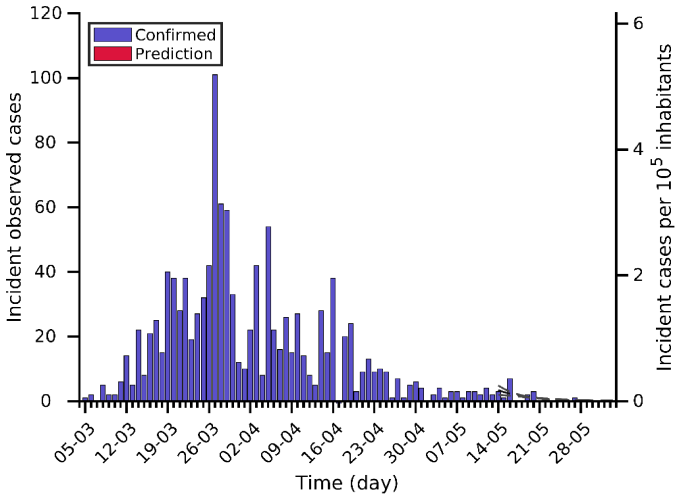
Calabria 28-05-2020. Population: 1.9M. Current cumulated incidence: 59/10^5

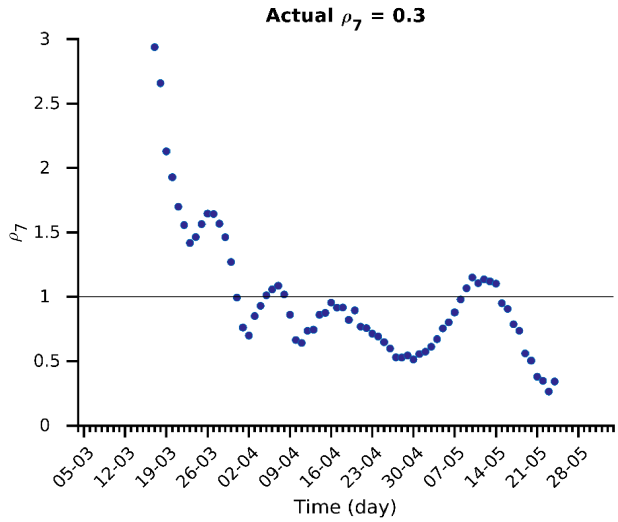


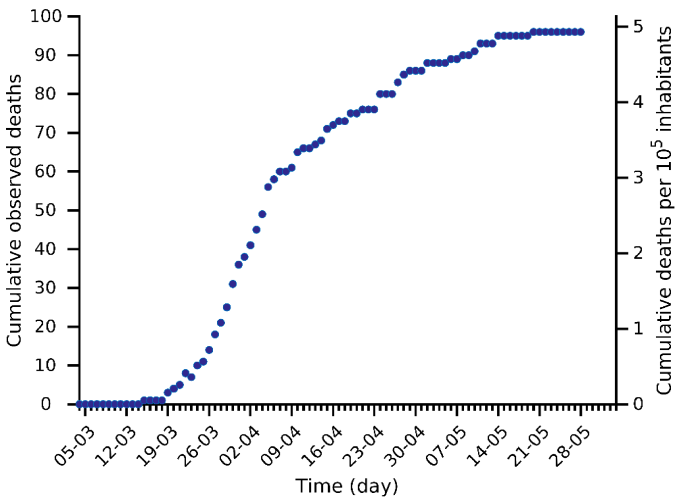


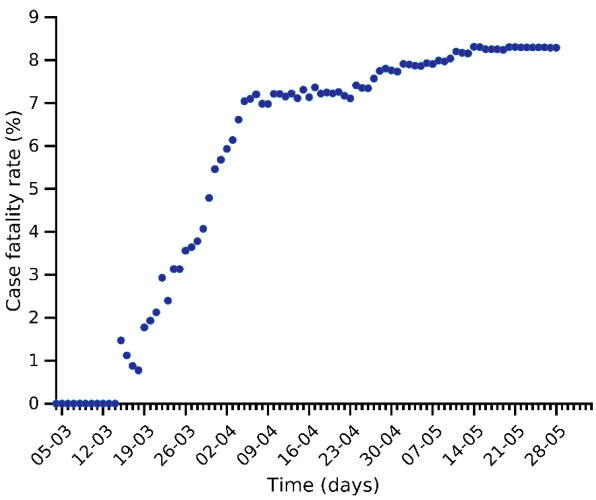




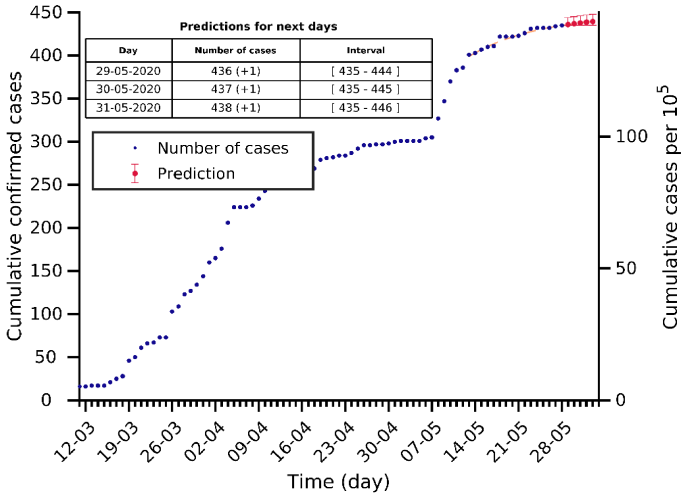


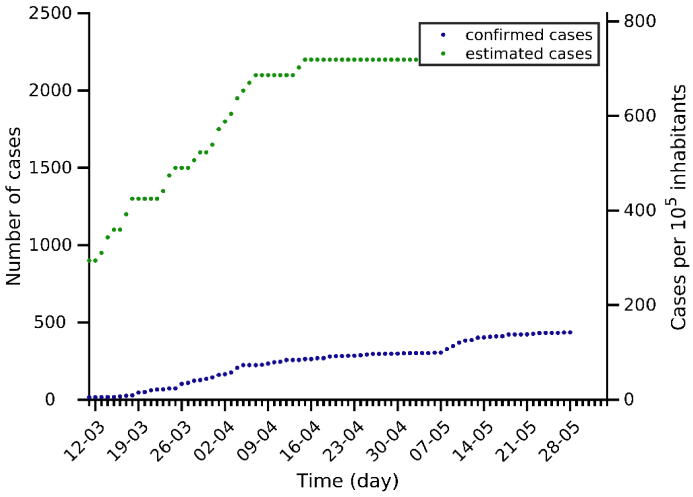


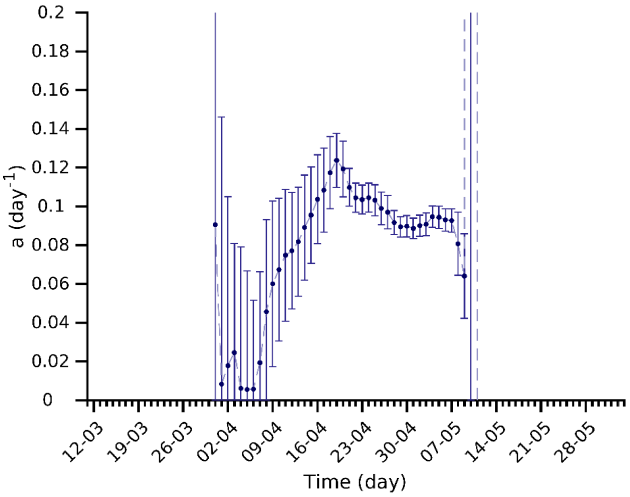


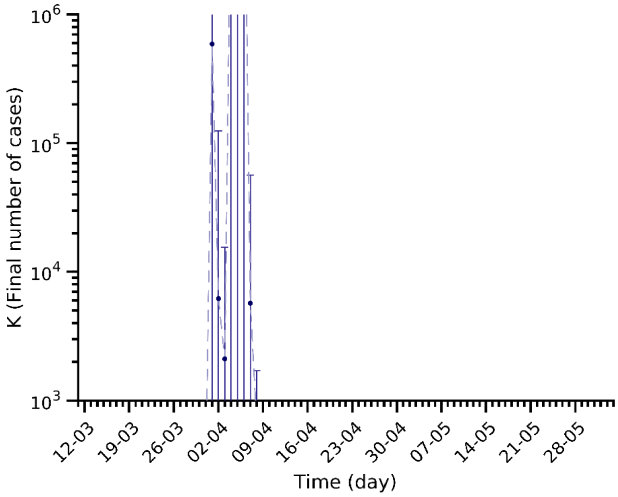


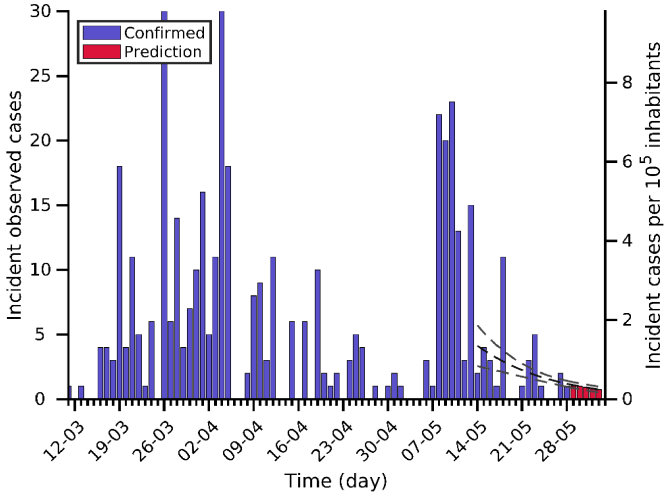
Molise 28-05-2020. Population: 0.3M. Current cumulated incidence: 142/10⁵

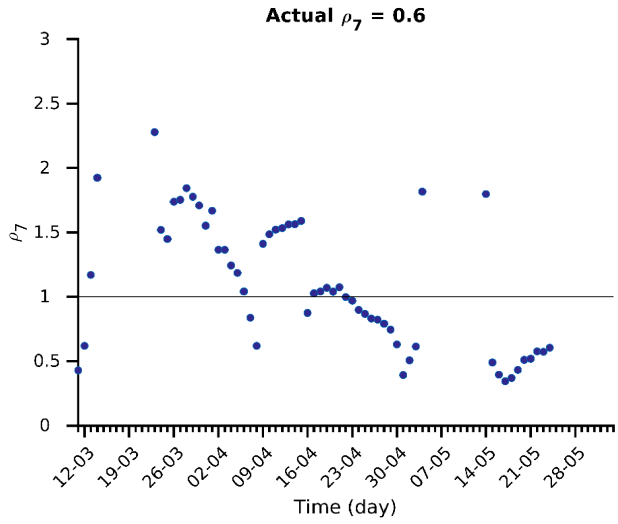


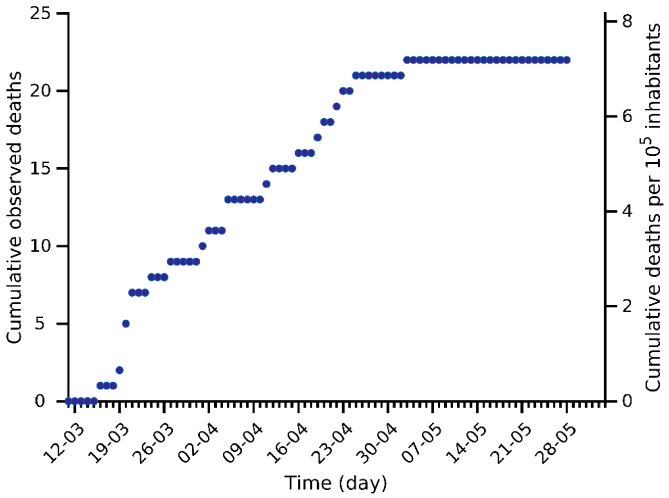


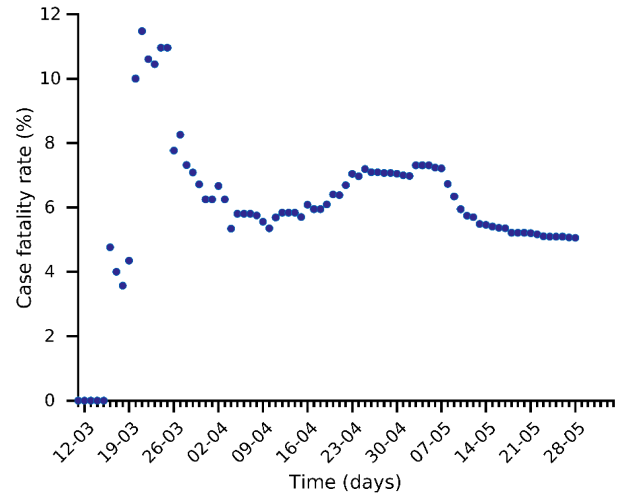




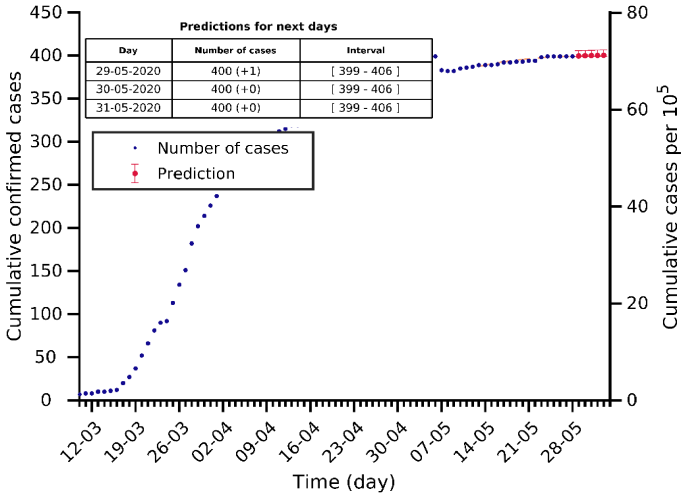


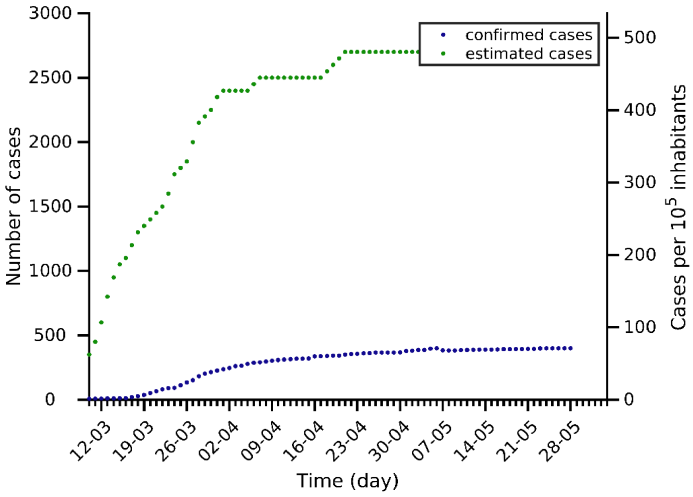


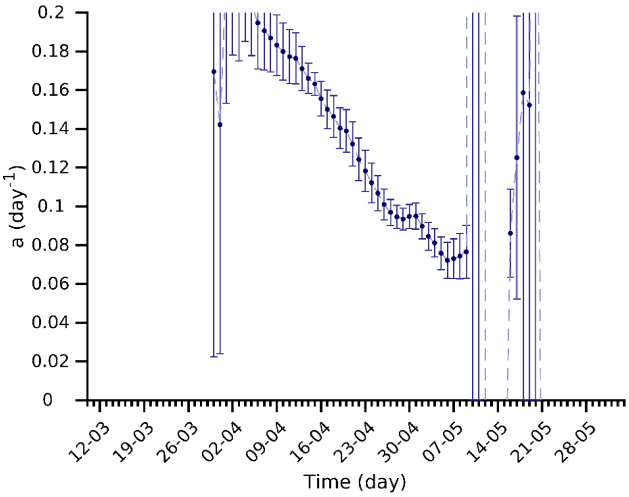


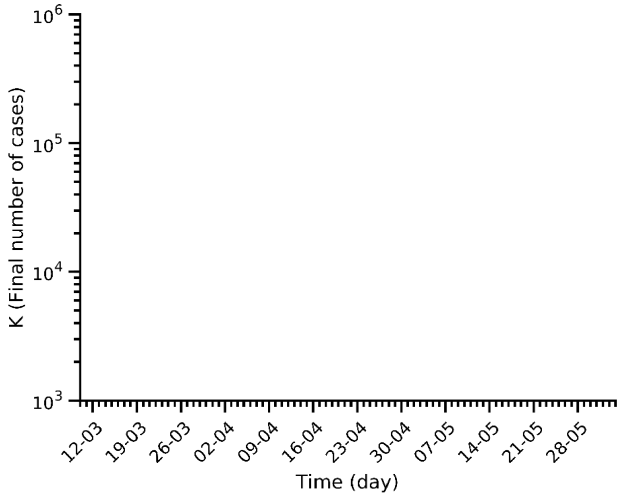


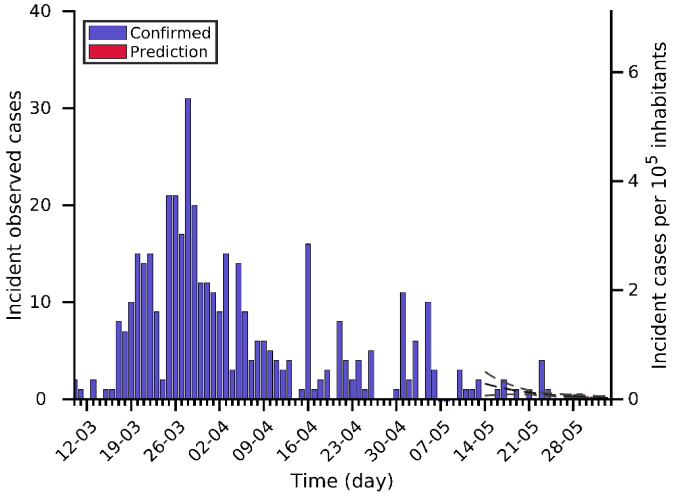
Basilicata 28-05-2020. Population: 0.6M. Current cumulated incidence: 71/10^5

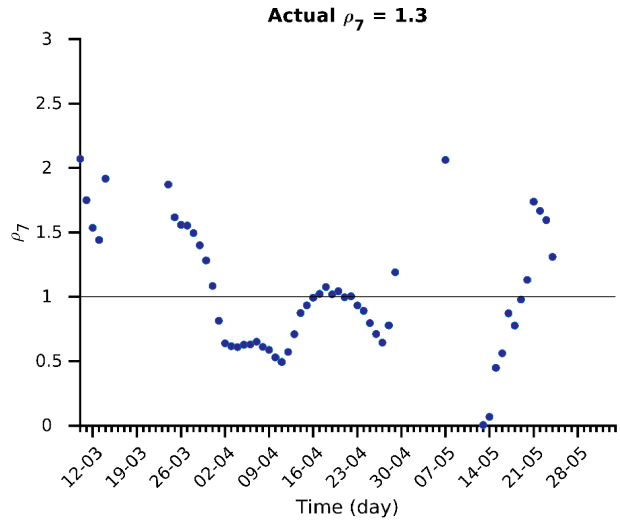


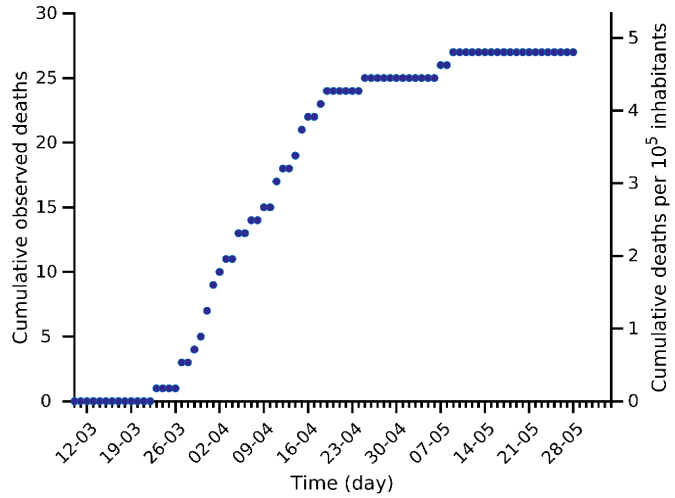


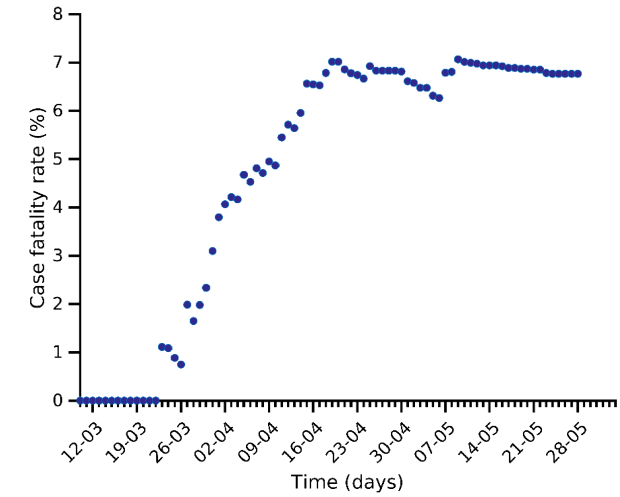












Methods

Methods

(1) Data source

Data are daily obtained from World Health Organization (WHO) surveillance reports[2], from European Centre for Disease Prevention and Control (ECDC)[3] and from Ministerio de Sanidad[4]. These reports are converted into text files that can be processed for subsequent analysis. Daily data comprise, among others: total confirmed cases, total confirmed new cases, total deaths, total new deaths. It must be considered that the report is always providing data from previous day. In the document we use the date at which the datapoint is assumed to belong, i.e., report from 15/03/2020 is giving data from 14/03/2020, the latter being used in the subsequent analysis.

(2) Data processing and plotting

Data are initially processed with Matlab in order to update timeseries, i.e., last datapoints are added to historical sequences. These timeseries are plotted for EU individual countries and for the UE as a whole:

- ✓ Number of cumulated confirmed cases, in blue dots
- ✓ Number of reported new cases
- ✓ Number of cumulated deaths

Then, two indicators are calculated and plotted, too:

- ✓ Number of cumulated deaths divided by the number of cumulated confirmed cases, and reported as a percentage; it is an indirect indicator of the diagnostic level.
- ✓ ρ: this variable is related with the reproduction number, i.e., with the number of new infections caused by a single case. It is evaluated as follows for the day before last report (*t-1*):

$$\rho(t-1) = \frac{N_{new}(t) + N_{new}(t-1) + N_{new}(t-2)}{N_{new}(t-5) + N_{new}(t-6) + N_{new}(t-7)}$$

where $N_{new}(t)$ is the number of new confirmed cases at day t.

(3) Classification of countries according to their status in the epidemic cycle

The evolution of confirmed cases shows a biphasic behaviour:

(I) an initial period where most of the cases are imported;
(II) a subsequent period where most of new cases occur because of local transmission.

Once in the stage II, mathematical models can be used to track evolutions and predict tendencies. Focusing on countries that are on stage II, we classify them in three groups:

- Group A: countries that have reported more than 100 cumulated cases for 10 consecutive days or more;
- Group B: countries that have reported more than 100 cumulated cases for 7 to 9 consecutive days;
- Group C: countries that have reported more than 100 cumulated cases for 4 to 6 days.

[2] https://www.who.int/emergencies/diseases/novel-coronavirus-2019/situation-reports
[3] https://www.ecdc.europa.eu/en/geographical-distribution-2019-ncov-cases
[4] https://www.mscbs.gob.es/profesionales/saludPublica/ccayes/alertasActual/nCov-China/situacionActual.htm https://github.com/datadista/datasets/tree/master/COVID%2019 , https://covid19.isciii.es/

(4) Fitting a mathematical model to data

Previous studies have shown that Gompertz model[5] correctly describes the Covid-19 epidemic in all analysed countries. It is an empirical model that starts with an exponential growth but that gradually decreases its specific growth rate. Therefore, it is adequate for describing an epidemic that is characterized by an initial exponential growth but a progressive decrease in spreading velocity provided that appropriate control measures are applied.

Gompertz model is described by the equation:

$$N(t) = K\, e^{-ln\left(\frac{K}{N_0}\right)\cdot e^{-a\cdot(t-t_0)}}$$

where *N(t)* is the cumulated number of confirmed cases at *t* (in days), and N_0 is the number of cumulated cases the day at day t_0. The model has two parameters:

- ✓ *a* is the velocity at which specific spreading rate is slowing down;
- ✓ *K* is the expected final number of cumulated cases at the end of the epidemic.

This model is fitted to reported cumulated cases of the UE and of countries in stage II that accomplish two criteria: 4 or more consecutive days with more than 100 cumulated cases, and at least one datapoint over 200 cases. Day t_0 is chosen as that one at which *N(t)* overpasses 100 cases. If more than 15 datapoints that accomplish the stated criteria are available, only the last 15 points are used. The fitting is done using Matlab's Curve Fitting package with Nonlinear Least Squares method, which also provides confidence intervals of fitted parameters (*a* and *K*) and the R^2 of the fitting. At the initial stages the dynamics is exponential and *K* cannot be correctly evaluated. In fact, at this stage the most relevant parameter is *a*. Fitted curves are incorporated to plots of cumulative reported cases with a dashed line. Once a new fitting is done, two plots are added to the country report:

- ✓ Evolution of fitted *a* with its error bars, i.e., values obtained on the fitting each day that the analysis has been carried out;
- ✓ Evolution of fitted *K* with its error bars, i.e., values obtained on the fitting each day that the analysis has been carried out; if lower error bar indicates a value that is lower than current number of cases, the error bar is truncated.

These plots illustrate the increase in fittings' confidence, as fitted values progressively stabilize around a certain value and error bars get smaller when the number of datapoints increases. In fact, in the case of countries, they are discarded and set as "Not enough data" if $a>0.2\ day^{-1}$, if $K>10^6$ or if the error in K overpasses 10^6.

It is worth to mention that the simplicity of this model and the lack of previous assumptions about the Covid-19 behaviour make it appropriate for universal use, i.e., it can be fitted to any country independently of its socioeconomic context and control strategy. Then, the model is capable of quantifying the observed dynamics in an objective and standard manner and predicting short-term tendencies.

(5) Using the model for predicting short-term tendencies

The model is finally used for a short-term prediction of the evolution of the cumulated number of cases. The predictions increase their reliability with the number of datapoints used in the fitting. Therefore, we consider three levels of prediction, depending on the country:

[5] Madden LV. Quantification of disease progression. Protection Ecology 1980; **2**: 159-176.

- Group A: prediction of expected cumulated cases for the following 3-5 days[6];
- Group B: prediction of expected cumulated cases for the following 2 days;
- Group C: prediction of expected cumulated cases for the following day.

The confidence interval of predictions is assessed with the Matlab function `predint`, with a 99% confidence level. These predictions are shown in the plots as red dots with corresponding error bars, and also gathered in the attached table. For series longer than 9 timepoints, last 3 points are weighted in the fitting so that changes in tendencies are well captured by the model.

(6) Estimating non-diagnosed cases

Lethality of Covid-19 has been estimated at around 1 % for Republic of Korea and the Diamond Princess cruise. Besides, median duration of viral shedding after Covid-19 onset has been estimated at 18.5 days for non-survivors[7] in a retrospective study in Wuhan. These data allow for an estimation of total number of cases, considering that the number of deaths at certain moment should be about 1 % of total cases 18.5 days before. This is valid for estimating cases of countries at stage II, since in stage I the deaths would be mostly due to the incidence at the country from which they were imported. We establish a threshold of 50 reported cases before starting this estimation.

Reported deaths are passed through a moving average filter of 5 points in order to smooth tendencies. Then, the corresponding number of cases is found assuming the 1 % lethality. Finally, these cases are distributed between 18 and 19 days before each one.

[6] At this moment we are testing predictions at 4 days for countries with more than 100 cumulated cases for 13-15 consecutive days, and 5 days for 16 or more days.

[7] Zhou et al., 2020. Clinical course and risk factors for mortality of adult inpatients with COVID-19 in Wuhan, China: a retrospective cohort study. The Lancet; March 9, doi: 10.1016/S0140-6736(20)30566-3